FKSM 21-26-1

MAP READING

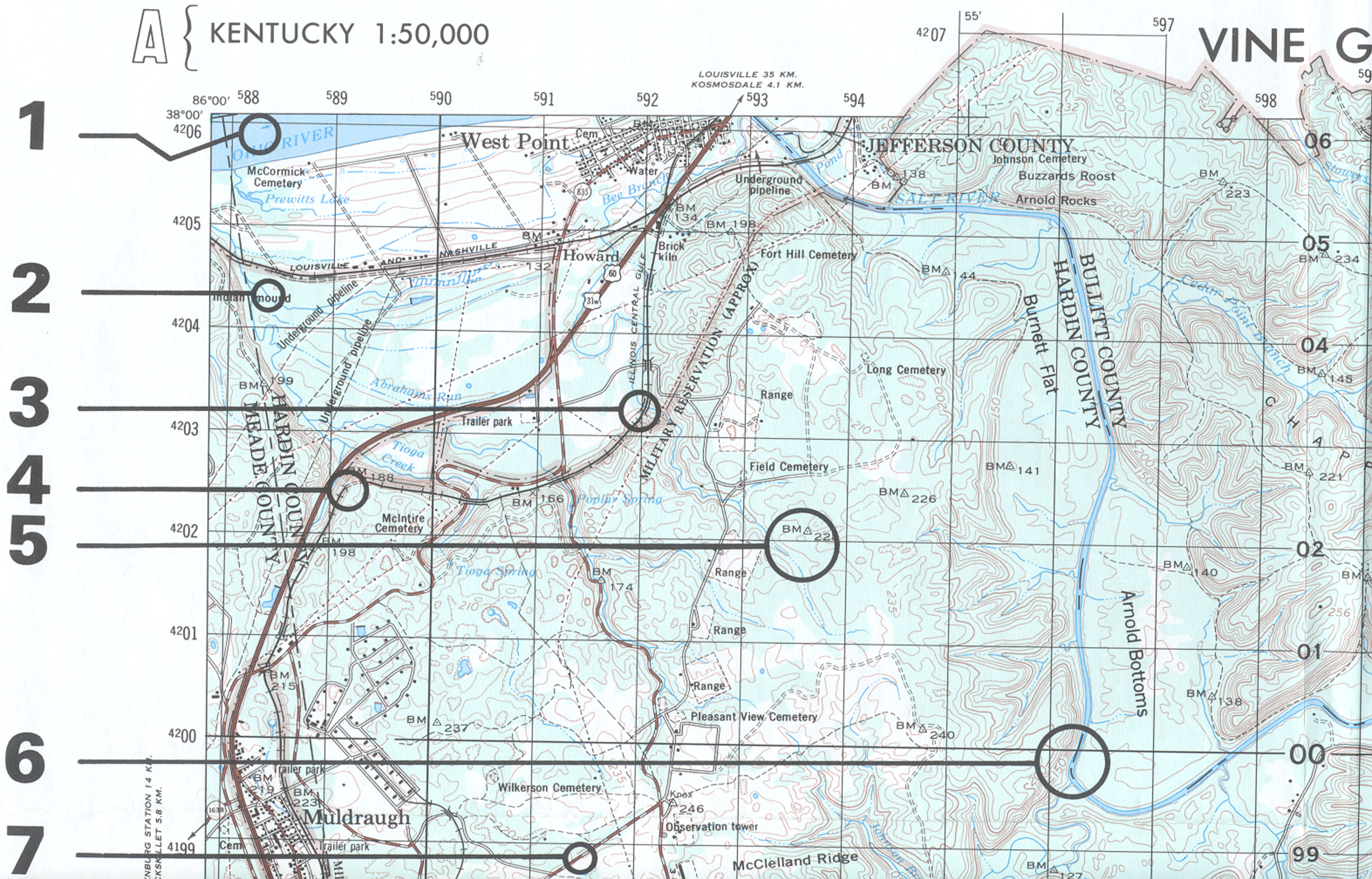
PROGRAMED TEXT

ARMOR

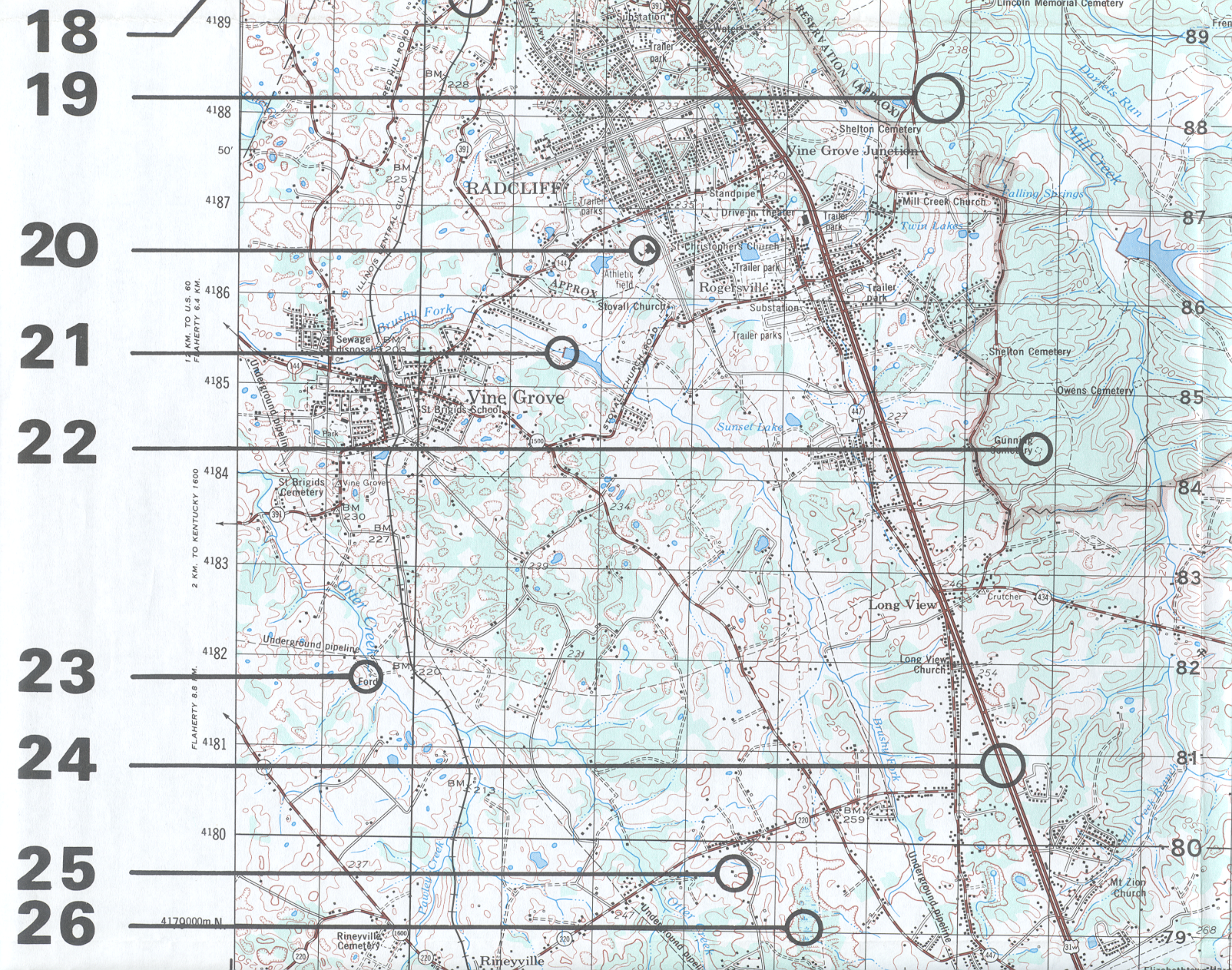
The Combat Arm of Decision

ARMOR OFFICER BASIC COURSE

TRAINING GROUP
US ARMY ARMOR CENTER
FORT KNOX, KENTUCKY
MAY 1983


A
KENTUCKY 1:50,000
VINE G
1
2
3
4
5
6
7
LOUISVILLE 35 KM.
KOSMOSDALE 4.1 KM.
West Point
Howard
Muldraugh
OHIO RIVER
SALT RIVER
JEFFERSON COUNTY
BULLITT COUNTY
HARDIN COUNTY
MEADE COUNTY
MILITARY RESERVATION (APPROX)
ILLINOIS CENTRAL GULF
LOUISVILLE AND NASHVILLE
McCormick Cemetery
Prewitts Lake
Indian mound
Underground pipeline
Abrahams Run
Trailer park
Tioga Creek
McIntire Cemetery
Tioga Spring
Poplar Spring
Brick kiln
Fort Hill Cemetery
Long Cemetery
Range
Field Cemetery
Pleasant View Cemetery
Wilkerson Cemetery
Observation tower
McClelland Ridge
Johnson Cemetery
Buzzards Roost
Arnold Rocks
Burnett Flat
Arnold Bottoms
Cedar Point Branch
Bee Branch
Pond
Cem


7
8
9
10
11
12
13
14
15
16
17
18
Muldraugh
Observation tower
McClelland Ridge
Hooker Mountain
FORT KNOX MILITA
Easy Gap
Muth Cemetery
Ray Cemetery
Davis Cemetery
Ranges
Range
Mill Creek
Canby Hill
Athletic field
Scott Mountain
Tip Top
Hart Cem
Van Voorhis Manor
GODMAN ARMY AIRFIELD (hard)
March Ridge
Cemetery
Calvin Cemetery
Hospital
FORT KNOX
Rose Terrace
Golf course
Post Cem
Gaffey Heights
Prichard Place
Pierce School
Scott Jr High School
High school
Gentry Cemetery
U.S. Bullion Depository
Cemetery
Dietz Acres
Golf course
3 LANES
MEADE COUNTY
HARDIN COUNTY
Cowley Cemetery
Radio tower (WSAC)
Sanders Spring Reservoir
Buffalo Branch
Red Hill
Red Hill Church
Radio tower
Substation
Lincoln Memorial Cemetery
Training area
BRANDENBURG STATION LICKSKILLET 5.8 KM.
IRVINGTON 27 KM. 9.8 KM. TO KENTUCKY 144
FLAHERTY 4.2 KM.



18
19
20
21
22
23
24
25
26
RADCLIFF
Vine Grove
Rogersville
Long View
Vine Grove Junction
Rineyville
St Brigids School
St Brigids Cemetery
St Christophers Church
Stovall Church
Shelton Cemetery
Owens Cemetery
Mill Creek Church
Long View Church
Mt Zion Church
Rineyville Cemetery
Lincoln Memorial Cemetery
Brushy Fork
Otter Creek
Pawley Creek
Mill Creek
Sunset Lake
Twin Lakes
Falling Springs
Dorrets Run
Mill Creek Branch
ILLINOIS CENTRAL GULF
RED HILL ROAD
STOVALL CHURCH ROAD
Underground pipeline
Sewage disposal
Athletic field
Standpipe
Drive-in theater
Trailer parks
Substation
Crutcher
Ford
12 KM. TO U.S. 60
FLAHERTY 6.4 KM.
2 KM. TO KENTUCKY 1600
FLAHERTY 8.8 KM.
4170000m N.

25
26

E

Prepared and published by the Defense Mapping Agency
Topographic Center, Washington, D. C.

G

Scale 1:

1000 500 0 1000
1000 500 0 1000 200
1 ½ 0 1
1 ½ 0

F

LEGEND

MAP INFORMATION AS OF 1977

ON THIS MAP, A LANE IS GENERALLY CONSIDERED AS BEING A MINIMUM OF 2.5 METERS (8 FEET) IN WIDTH.

ROADS

- Divided highway with median strip
- Primary all-weather, hard surface — 3 LANES
- Secondary all-weather, hard surface — 3 LANES
- Light duty all-weather, hard or improved surface
- Fair or dry-weather, unimproved surface
- Trail
- Route markers: Interstate; Federal; State — 95 200 301

BRIDGES

- Overpass; Underpass
- Highway bridge; Footbridge
- Railroad bridge

RAILROADS — Single track / Multiple track

- Standard gauge 1.44 meters (4′8½″)
- Narrow-gauge

BOUNDARIES

- National
- State or territory
- County or parish, with marker
- Civil township, precinct, town, barrio
- Incorporated city, village, town, hamlet
- Reservation: National, state; Military — MIL RES

- Buildings or structures
- Church; School
- Tanks; Windmill
- Power transmission line
- Benchmarks: Monumented; Non-monumented — BM×231 ×231
- Horizontal control station
- Spot elevations in meters: Checked; Unchecked — •227 •227
- Mine or quarry
- Levee; Cut; Fill
- Woodland
- Scattered trees
- Orchard
- Marsh or swamp
- Disappearing stream
- Dissipating stream
- Dam: Masonry; Earthen
- Intermittent lake
- Spring; Well
- Intermittent stream

H

CONTOUR INTER
SUPPLEMENTARY CO

SPHEROID . . . .
GRID . . . .
PROJECTION . . . .
VERTICAL DATUM . . . . NATI
HORIZONTAL DATUM . . . .
CONTROL BY . . . .
PRINTED BY . . . . DEFENSE MAP

I

SAMPLE 1,000 METER GRID SQUARE

46
× Sample point
45
12 13

100,000 M. SQUARE IDENTIFICATION

ET | FT
ES | FS
4200
600

GRID ZONE DESIGNATION

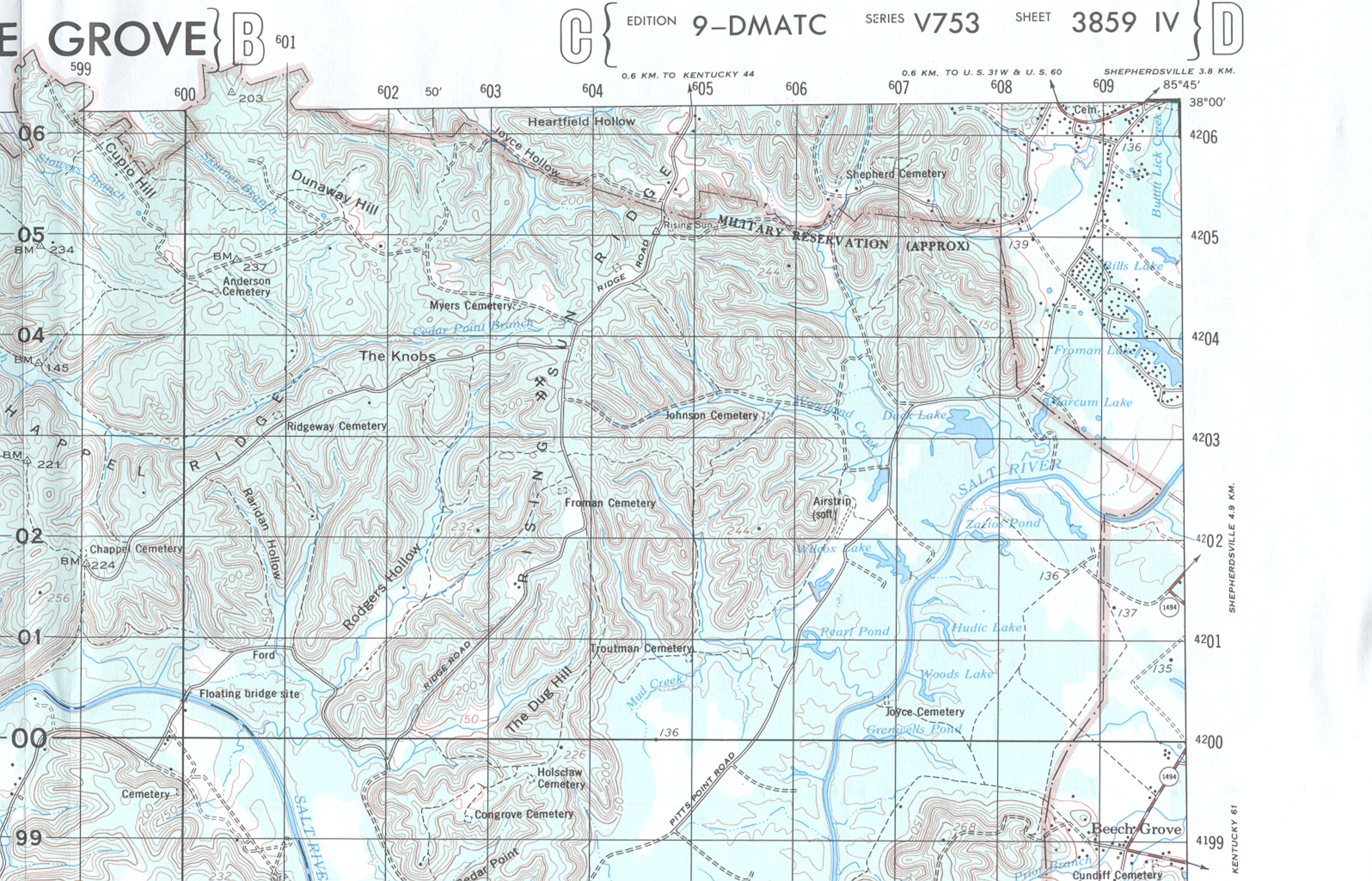
16S

1. Rea
line
fro
2. Rea
gri
met

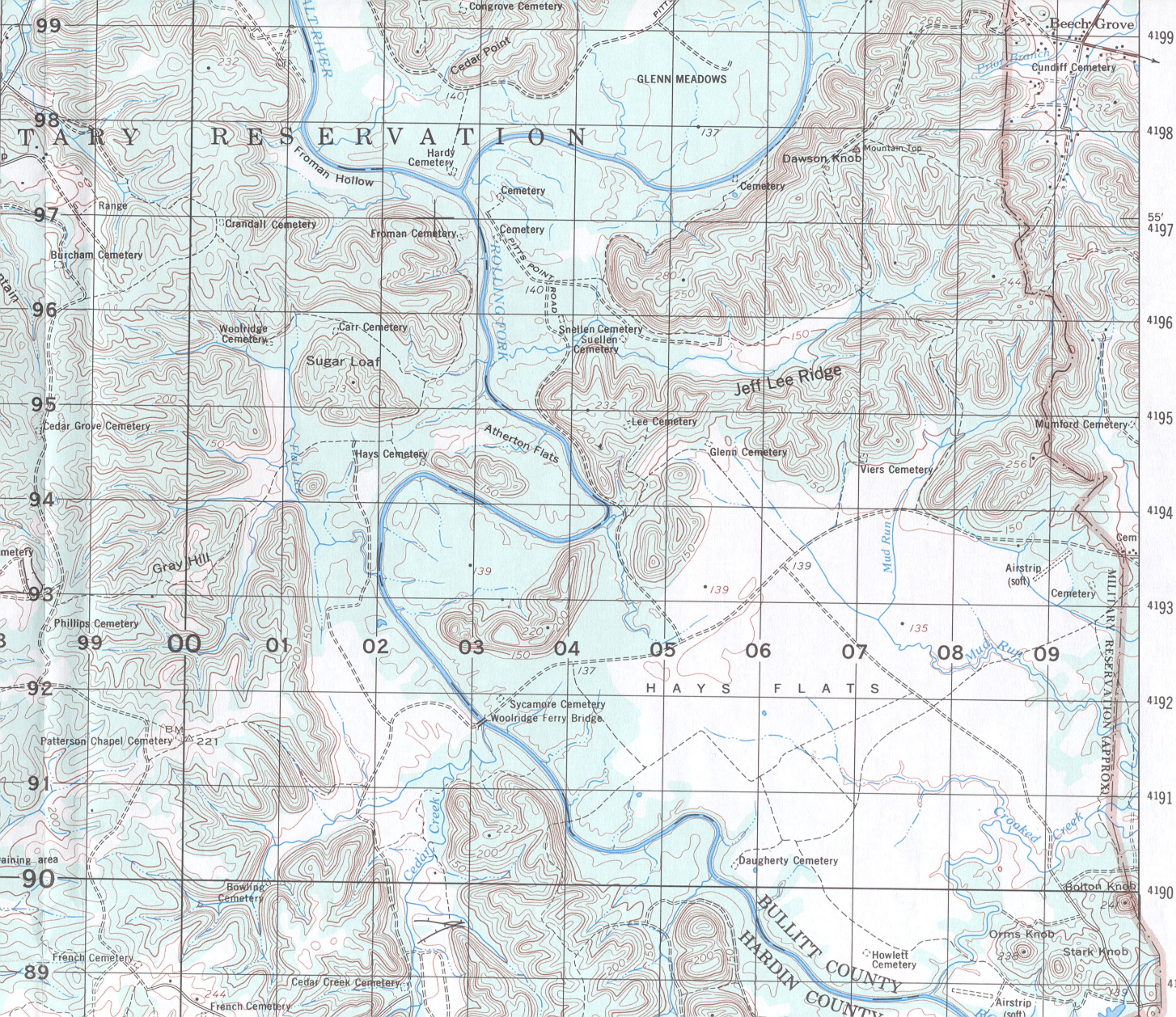
WHE
METE
LIES,
IDEN

WHE
DESI
PREF

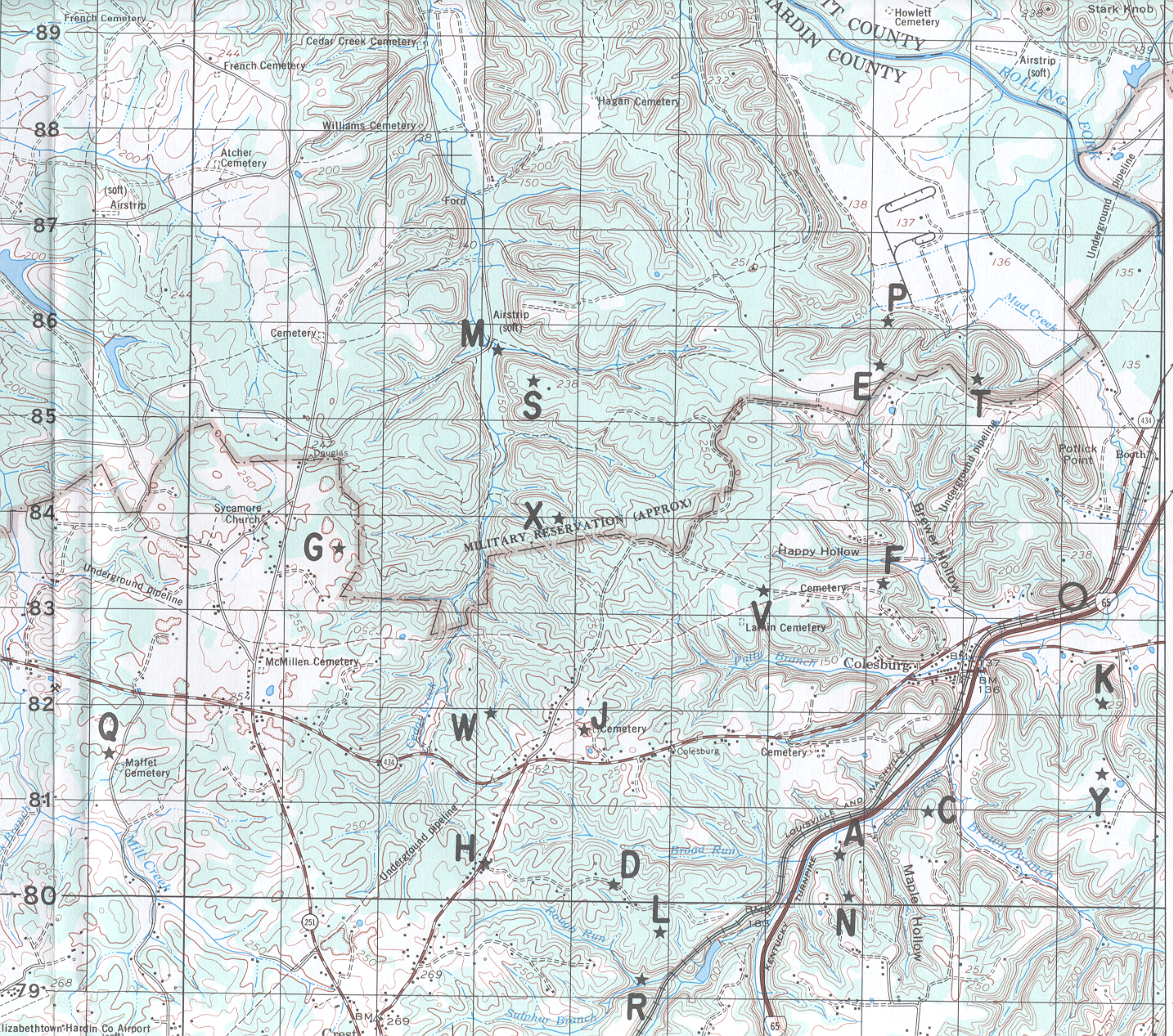
SHEET 3859 IV SERIES V753 EDITION 9–DMATC VINE GROVE



E GROVE
B
C
EDITION 9-DMATC
SERIES V753
SHEET 3859 IV
D
0.6 KM. TO KENTUCKY 44
0.6 KM. TO U. S. 31W & U. S. 60
SHEPHERDSVILLE 3.8 KM.
SHEPHERDSVILLE 4.9 KM.
KENTUCKY 61
85°45′
38°00′
50′
MILITARY RESERVATION (APPROX)
Heartfield Hollow
Joyce Hollow
Shepherd Cemetery
Cem.
Bullitt Lick Creek
Bills Lake
Froman Lake
Marcum Lake
Duck Lake
Woodland Creek
SALT RIVER
Rising Sun
RIDGE ROAD
Cupio Hill
Dunaway Hill
Skinner Branch
Stoners Branch
Anderson Cemetery
Myers Cemetery
Cedar Point Branch
The Knobs
Johnson Cemetery
Ridgeway Cemetery
Raridan Hollow
Chappel Cemetery
Froman Cemetery
Airstrip (soft)
Wilcox Lake
Zazios Pond
Pearl Pond
Hudic Lake
Woods Lake
Joyce Cemetery
Grenwells Pond
Rodgers Hollow
Troutman Cemetery
Mud Creek
Ford
Floating bridge site
The Dug Hill
PITTS POINT ROAD
Holsclaw Cemetery
Congrove Cemetery
Cemetery
Beech Grove
Prior Branch
Cundiff Cemetery
1494



4.8 KM. TO KENTUCKY 61
Beech Grove
Cundiff Cemetery
Prior Branch
Congrove Cemetery
Cedar Point
GLENN MEADOWS
TARY RESERVATION
Froman Hollow
Hardy Cemetery
Cemetery
Dawson Knob
Mountain Top
Range
Crandall Cemetery
Froman Cemetery
PITTS POINT ROAD
ROLLING FORK
SALT RIVER
Burcham Cemetery
Woolridge Cemetery
Carr Cemetery
Snellen Cemetery
Suellen Cemetery
Sugar Loaf
Jeff Lee Ridge
Cedar Grove Cemetery
Lee Cemetery
Mumford Cemetery
Hays Cemetery
Atherton Flats
Glenn Cemetery
Viers Cemetery
Flat Lick
Gray Hill
Mud Run
Airstrip (soft)
Cemetery
Cem
MILITARY RESERVATION (APPROX)
Phillips Cemetery
HAYS FLATS
Sycamore Cemetery
Woolridge Ferry Bridge
Patterson Chapel Cemetery
BM 221
Cedar Creek
Crooked Creek
Daugherty Cemetery
Training area
Bowling Cemetery
Bolton Knob
BULLITT COUNTY
HARDIN COUNTY
Howlett Cemetery
Orms Knob
Stark Knob
French Cemetery
Cedar Creek Cemetery
French Cemetery
Airstrip (soft)
99 00 01 02 03 04 05 06 07 08 09
4199 4198 55′ 4197 4196 4195 4194 4193 4192 4191 4190 4189



TYPICAL RELIEF FEATURES

A to N — Valley
D to H — Ridge
L to R — Draw
M to S — Spur

G — Depress
T — Saddle
X — Hill

Inside the O — (No Star) Cliff

98 599 600 601 602 50' 603 604 605 606 607 608 609 610 85°45'

TOWN 7.2 KM.

ELIZABETHTOWN 6.7 KM.

5.4 KM. TO INTERCHANGE 93
ELIZABETHTOWN 10 KM.

Scale 1:50,000

1000 2000 3000 4000 5000 Meters

1000 2000 3000 4000 5000 Yards

1 2 3 Statute Miles

1 2 3 Nautical Miles

CONTOUR INTERVAL 10 METERS
SUPPLEMENTARY CONTOURS 5 METERS

. . . . CLARKE 1866
. . . . 1,000 METER, UTM ZONE 16
. . . . TRANSVERSE MERCATOR
. . . . NATIONAL GEODETIC VERTICAL DATUM OF 1929
. . . . 1927 NORTH AMERICAN DATUM
. . . . USGS, NGS, AND CE
. . . . . . DEFENSE MAPPING AGENCY TOPOGRAPHIC CENTER 3-78

GRID SQUARE
46
45
13
IDENTIFICATION
4200
GNATION

100 METER REFERENCE

1. Read large numbers labeling the VERTICAL grid line left of point and estimate tenths (100 meters) from grid line to point. 12 3
2. Read large numbers labeling the HORIZONTAL grid line below point and estimate tenths (100 meters) from grid line to point. 45 6

Example: 123456

WHEN REPORTING OUTSIDE THE 100,000 METER SQUARE AREA IN WHICH THE POINT LIES, PREFIX THE 100,000 METER SQUARE IDENTIFICATION.

Example: ES123456

WHEN REPORTING OUTSIDE THE GRID ZONE DESIGNATION AREA IN WHICH THE POINT LIES, PREFIX THE GRID ZONE DESIGNATION.

Example: 16SES123456

J

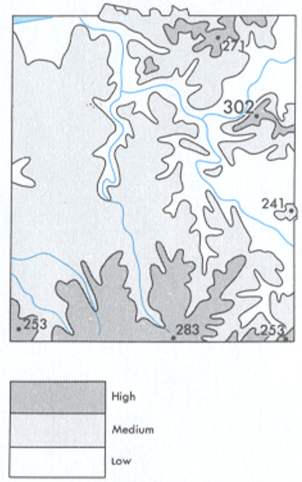
1975
G-M ANGLE
½° (10 MILS)

GRID CONVERGENCE
0°41' (12 MILS)
FOR CENTER OF SHEET

TO CONVERT A
MAGNETIC AZIMUTH
TO A GRID AZIMUTH
SUBTRACT G-M ANGLE

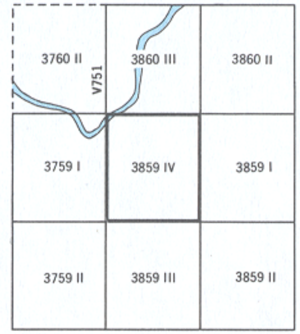
TO CONVERT A
GRID AZIMUTH TO A
MAGNETIC AZIMUTH
ADD G-M ANGLE

ELEVATION GUIDE



K

ADJOINING SHEETS



L

BOUNDARIES

Kentucky
A. Meade County
B. Hardin County
C. Bullitt County
D. Jefferson County

Indiana
E. Harrison County
1. Taylor Township

M

THIS MAP IS RED LIGHT READABLE

USERS SHOULD REFER CORRECTIONS, ADDITIONS, AND COMMENTS FOR IMPROVING THIS PRODUCT TO DIRECTOR, DEFENSE MAPPING AGENCY TOPOGRAPHIC CENTER, WASHINGTON, D. C. 20315, ATTN: D/PPO.

STOCK NO. V753X38594

USAARMS Special Text 21-26-1

BASIC MAP READING

Table of Contents

•Lesson Three:

SPECIAL TEXT OF THE US ARMY ARMOR SCHOOL

ST 21-26-1

BASIC MAP READING

General Instructions

1. This text consists of three lessons:

   a. Lesson 1 - Marginal Information, Map Symbols, Military Grid, Scale and Distance.

   b. Lesson 2 - Angles, Directions, and Use of the Compass.

   c. Lesson 3 - Intersection, Resection, Elevation, and Intervisibility Profiles.

2. Text and materials furnished: Vine Grove map sheet (overprint). You will need a coordinate scale/protractor, GTA 5-2-12, 1981.

3. Students in the Armor Officer Basic Course should skim objectives 1, 3 4, 5, and 8. They should complete learning objectives 2 and 9. These two learning objectives are, historically, the objectives with most NO GO on the Map Reading Diagnostic Examination (CA.01004).

4. You may work only the learning activity(ies) that you feel you should concentrate upon, or you may work the entire text. If you do, you should work the practice exercises in order. Regardless, study practical exercise accompanying solutions as thoroughly as you do the study resources, since they will help you completely. If you incorrectly answer or solve a practice item, recheck the study resources and make sure that you understand the solution.

5. You may spend an unlimited number of hours on this text. However, as a guide, the actual time (in hours) required to complete the study resources, practice exercise, should be approximately six to eight hours.

6. The exercises in this text are multiple-choice. Each statement is followed by four or five possible answers; select the best answer and mark your selection in the booklet.

> *NOTE*
>
> *This Special Text is adapted from US Army Institute for Professional Development Correspondence Course ARO-120. Only minimal changes in text have been incorporated. You may ignore any references to examinations, group study, etcetera. Learning Objectives have been re-numbered sequentially.*

STATEMENT

The words "he, his" are intended to include both the masculine and feminine genders. Any exception to this will be so noted.

INTRODUCTION

Map Reading is a valuable military skill that must be learned and practiced by all soldiers and military leaders to accomplish the daily missions of training an army and surviving in combat.

A map provides comprehensive information on the existance and location of, and the distances between, man-made features (i.e., populated areas, routes of travel and communication) and the extent of vegetation coverage. It also indicates variation in land forms and heights of natural features. These variations in land forms, or terrain features are the primary reason for the existance of the map -- they are the most important features shown.

With our military forces dispersed throughout the world, it is necessary to rely on maps to supply information to resolve our operational and logistical problems caused by operations far from our own shores. Troops and vast amounts of materials must be transported, stored, and phased into an operation at the proper time and place. To accomplish these operations without a map would be impossible. Conversely, for one to participate in these operations without adequate map reading skills could seriously impair the mission, and in some instances cause loss of life. By necessity, much of military planning must be done with maps. However, the finest maps are worthless unless the soldier or map user known how to read them.

A topographic map (a description of man-made and geographic features of a relatively small area) is a mathematically determined presentation of a portion of the earth's surface, systematically plotted to scale upon a plane surface. The man-made and natural features are depicted by symbols, lines, colors, and forms.

NOTE: All learning activities are systematically incorporated into this subcourse to prepare the student to perform three terminal objectives:

1. Determine the location of a point using the military grid reference system
2. Navigate on roads and cross-country using a map
3. Conduct a map reconnaissance to identify and select routes and positions.

This subcourse is based on FM 21-26, "Map Reading", FM 21-31, "Topographical Symbols", and other material approved for US Army Armor Center Instruction. It reflects the current position of the US Army Armor Center and conforms to published Department of Army doctrine.

LESSON ONE

OBJECTIVE:	Task No.: To be determined.
TASK:	At the end of this lesson, you will be able to answer questions on marginal information, map symbols, military grids, the US Military Grid Reference System, scale, and distance.
CONDITIONS:	You will have Subcourse Booklet AR0120 and an examination response sheet. You will work at your own pace and in your own selected environment with no supervision.
STANDARDS:	Within approximately three hours you should be able to study the lesson, answer the practice exercise questions, and select the correct response for each examination question. You must respond correctly to 75 percent of the examination questions in order to receive credit for the subcourse.
CREDIT HOURS:	3.
REFERENCES:	FM 21-26, "Map Reading" and FM 21-31, "Topographical Symbols."

1-1. LEARNING ACTIVITY--OBJECTIVE 1

Upon completion of this learning activity, you will be able to explain and locate marginal information and identify topographical symbols on a military map.

a. Study Resources--Objective 1.

(1) Marginal information is information located on the border or outer edge of the geographic scaled drawing on a map sheet. Basically, a map sheet is made up of two recognizable sections: the scaled drawing and the margin. Items of useful information that will be helpful to the map user are printed in the margin. The marginal information may not appear in the same position on each map; however, a glance at the outer edge of the map sheet will usually reveal the following information (fig 1-1):

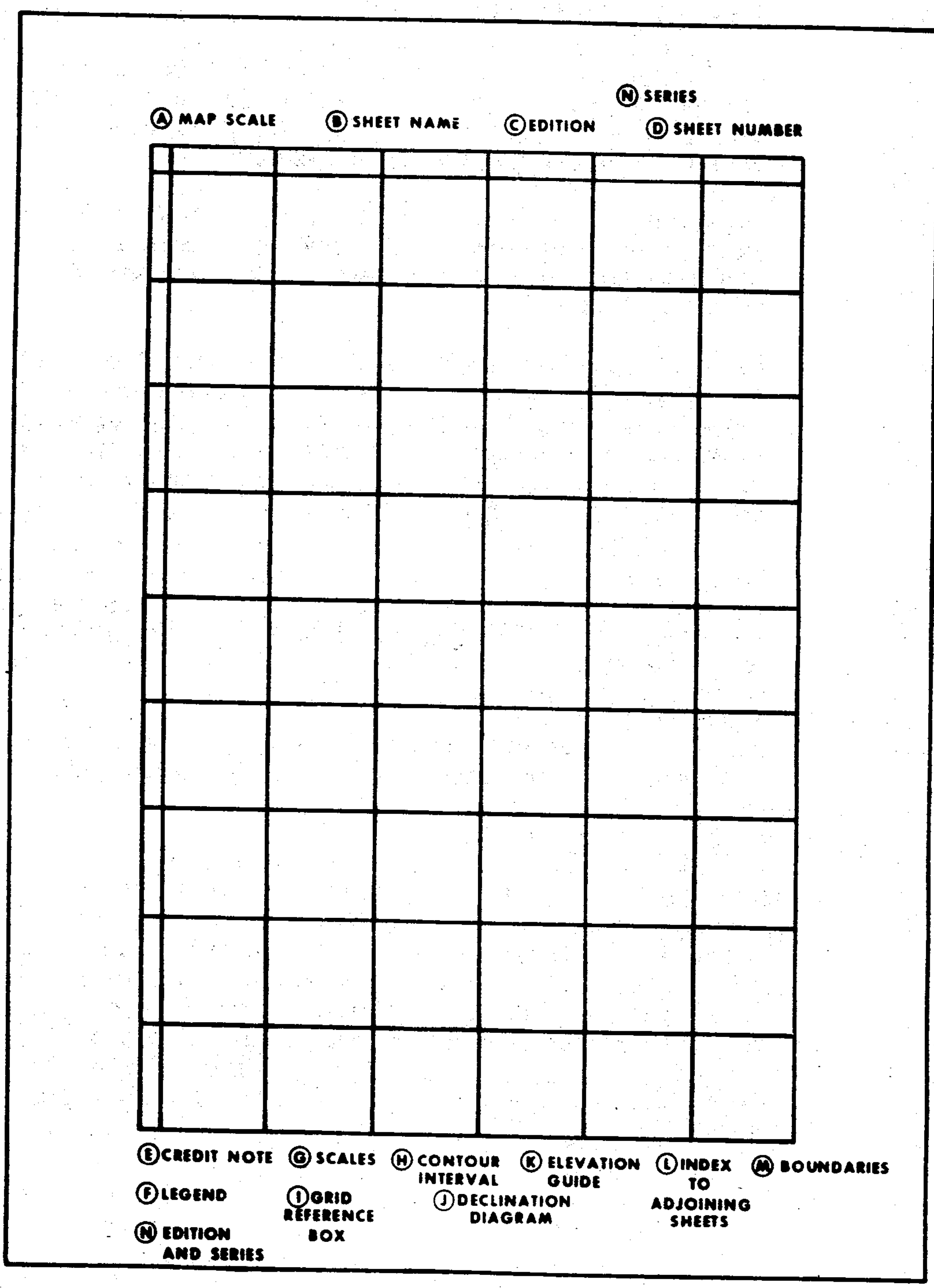


Figure 1-1. Marginal information.

a (B) Sheet Name. The sheet name is found in the center of the upper margin of the map. Generally, a map is named after its most outstanding cultural or geographical feature (fig 1-2).

Figure 1-2. Sheet name.

(b) (D) Series and Sheet Number. The series and sheet number are found in the upper left margin. The sheet number of Vine Grove map, 3859 IV (fig 1-3) identifies that particular sheet in the adjoining sheets diagram. The adjoining sheets diagram in the lower right margin of this map is explained in paragraph (c). The series number will change from state to state in the United States. Each foreign country has its own series numbers.

SHEET 3859 IV

Figure 1-3. Sheet number.

(c) (L) Index to Adjoining Sheets. The index to adjoining map sheets appears in the extreme right of the lower margin. All standard scale maps contain a diagram that illustrates adjoining map sheets. The diagram usually contains nine rectangles. The center rectangle represents the map being used or under consideration. The others represent the adjoining sheets. The number of rectangles in the index may vary, depending on the locations of the adjoining sheets; however, all sheets are identified by their respective number, located in the center of each rectangle (fig 1-4). The index to adjoining map sheets is used in determining the requirements for additional maps. If the planned tactical operation is to be extended into an area not covered by the user's map, identification of the maps needed can be obtained from adjoining sheets diagram. Sheet number 3760II is in a different series and is shown with a dash outline.

ADJOINING SHEETS

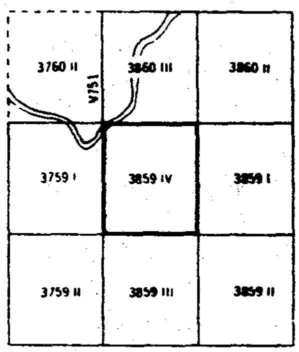


Figure 1-4. Index to adjoining sheets.

(d) Ⓙ Declination Diagram. Also located in the lower right margin is the declination diagram. The declination diagram is very important to the user, especially when necessary to navigate from point A to point B on a map using a compass. The declination shows the interrelationship of magnetic north, grid north, and true north (fig 1-5). Declination is the angular difference between true north and either magnetic or grid north.

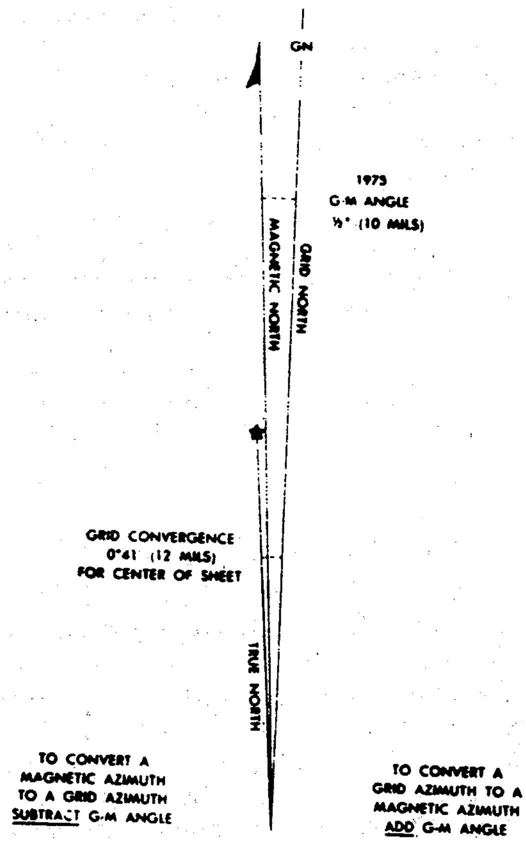


Figure 1-5. Declination diagram.

(e) Ⓖ and Ⓐ Scales. The map scale and graphic (bar) scale are located in the center of the lower margin of the map. Map scale, expressed as a representative fraction (RF, 1:50,000), gives the ratio of map distance to ground distance. The scale of the map is also located in the upper left margin. The graphic bar scales are used for the determination of ground distance. Bar graphic scales are rulers and are located in the center of the lower margin. They are ruled representations of ground surface, each in a different unit of measurement, drawn to map scale.

1 May have from one to four bar scales (figs 1-6 and 1-7).

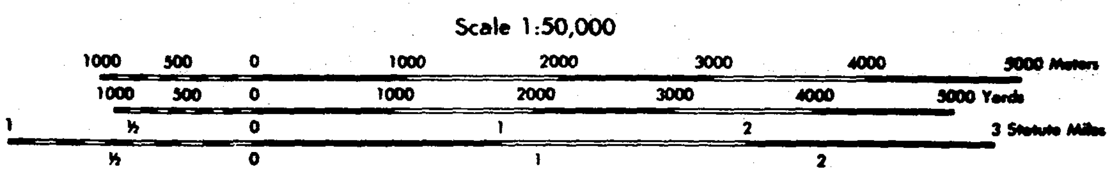


Figure 1-6. Three-bar scale.

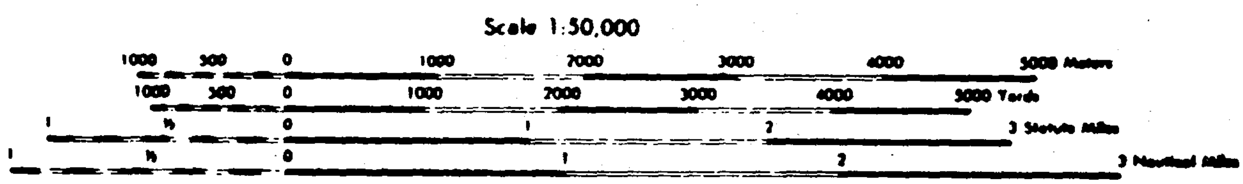


Figure 1-7. Four-bar scale.

2 Usually, bar scales facilitate measurement in at least meters and miles. The meter is the US Army's most common unit of measurement. The nautical mile is 800 feet longer than the statute mile and is seldomed used in land navigation.

3 Each bar scale is made up of two scales, a primary and an extension scale (fig 1-8). The portion of the scale marked off to the right of 0 is divided into full units (i.e., statute miles, kilometers, 1,000 yards), while the scale to the left of the 0, the extension scale, is divided into tenths (i.e., 1/10 mile and 100 meters). The extension scale enables measurements of distances that are not exact multiples of the divisions on the primary scale. The bar scale will play a vital role in determining distances to be computed at later lessons in this subcourse.

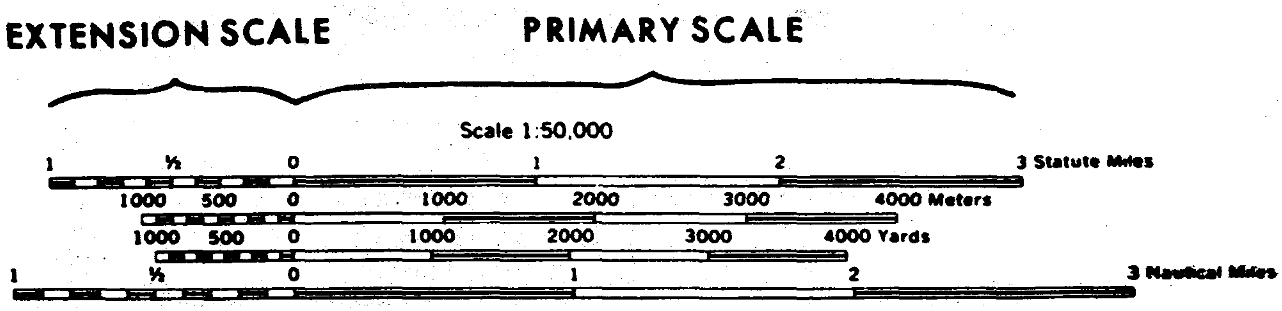


Figure 1-8. Primary and extension scales.

(f) (H) Contour Interval Note. The contour interval note appears in the center of the lower margin. The contour interval is the vertical distance between elevations represented by two contour lines on a map (fig 1-9).

CONTOUR INTERVAL 10 METERS
SUPPLEMENTARY CONTOURS 5 METERS

Figure 1-9. Contour intervals.

(g) (E) Credit Note. The credit note appears in the upper portion of the bottom margin on the extreme left. This information names the controlling agency, the date the map was compiled, and when it was printed (fig 1-10).

Prepared and published by the Defense Mapping Agency
Topographic Center, Washington, D. C.

Figure 1-10. Credit note.

(h) (I) Grid Reference Box. The grid reference box is usually located in the center of the lower margin. It contains information for identifying the grid zone designation and the 100,000-meter square in which the area represented by the map is located. It provides instruction for giving grid references on the map (fig 1-11).

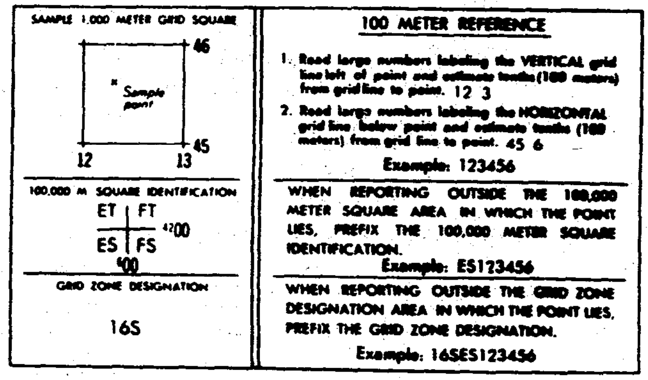


Figure 1-11. Grid reference box.

(i) Ⓕ Legend. The legend appears in the lower left margin of the map. It is a small portion of the map-maker's dictionary, his shorthand method of identifying mapped features. These symbols are called topograrahic symbols. To increase their value and for ease of identification, the following colors are standard:

1. Black...classification of man-made features such as a road, mine, quarry, or building.
2. Red...classification of man-made features, such as roads and built/up areas, as to use or type.
3. Blue...drainage; i.e., stream, river, lake, or swamp.
4. Green...vegetation; i.e., orchard, grassland, or woods.
5. Brown...elevation and relief; i.e., contour lines and hachures. (fig 1-12).

Note: The symbols are enlarged from six to ten times above scale so that you may easily read them in dim light. The map-maker will place the <u>center of the symbol</u> directly on the point where the object represented is located. Symbol design is logical, and the symbol will very much resemble what you would see on the ground if you looked down from an aircraft.

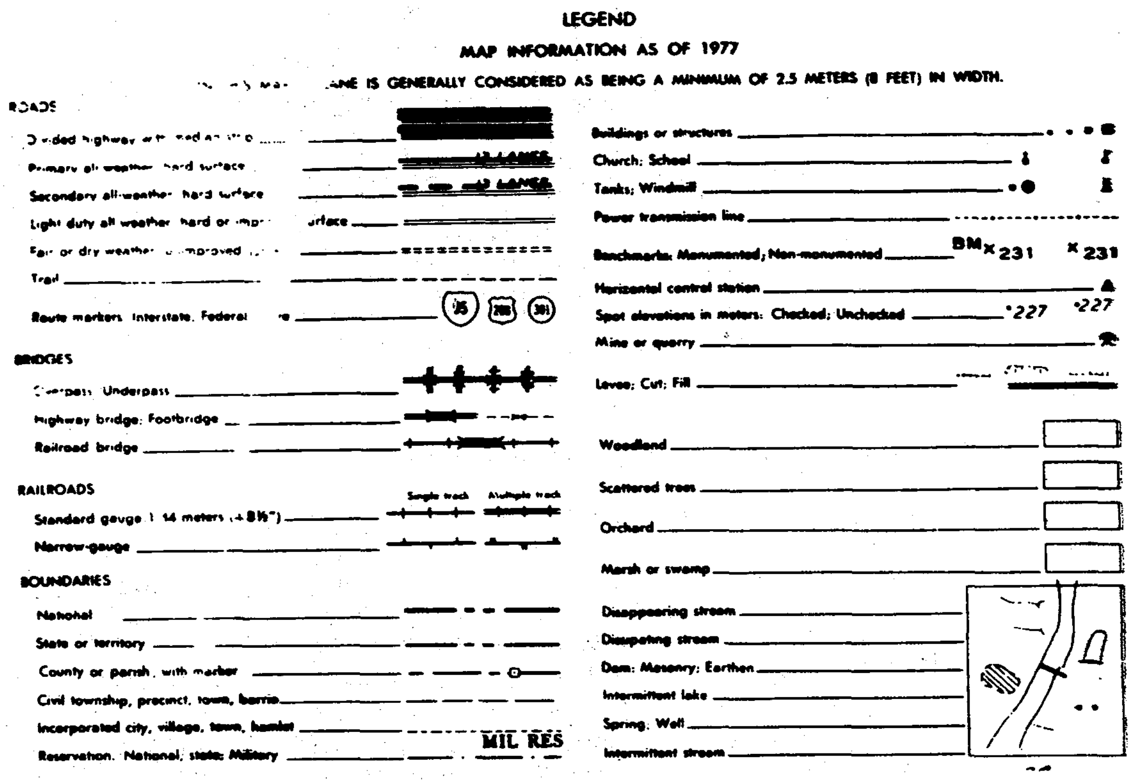


Figure 1-12. Legend.

(j) Ⓚ Elevation Guide. An elevation guide is provided on some large-scale maps. The elevation guide (fig 1-14) found in the lower right margin of the Vine Grove map is a miniature characterization of the terrain. In the elevation guide the terrain is represented by bands of elevation, spot elevations, and major drainage features. Thus, the elevation guide provides a means for rapid recognition of land forms. The elevation guide can greatly help orient your map by terrain association (fig 1-13).

ELEVATION GUIDE

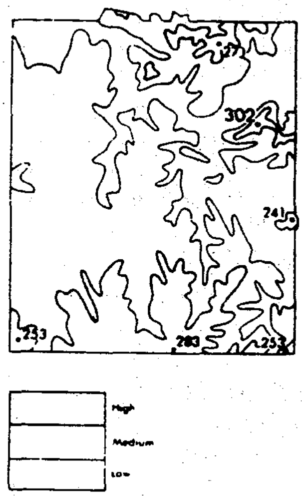


Figure 1-13. Elevation guide.

(k) Ⓜ Index to Boundaries. The index to boundaries appears in the lower right margin, to the right of the index to adjoining map sheets. This diagram shows boundaries which will occur within the map area, such as county lines and state boundaries. While county and state boundaries are usually of little significance, national boundaries can be very important. Each area is identified by a number corresponding to the name listed beneath the diagram. The index to boundaries may appear above the index to adjoining map sheets on some maps. On the Vine Grove map, locate this index and note the boundaries for future reference (fig 1-14).

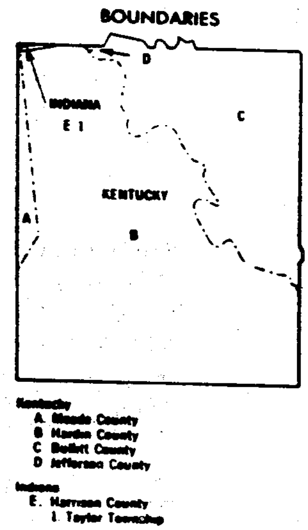


Figure 1-14. Index to boundaries.

(1) Ⓝ Edition and Series. The edition number and the series number are very useful to the map user. The edition number of a map appears in the upper right margin and in the lower left margin. It represents the age of the map in relationship to other editions of the same map, as well as the agency responsible for its publication. The edition number on your Vine Grove map is 9, indicating that this is the 9th edition of this map. "DMATC" indicated that this edition was prepared by the Defense Mapping Agency Topographic Center. Edition numbers run consecutively. A map bearing a higher edition number contains more recent information than that same map with a lower edition number. Therefore, when selecting a map, select the one bearing the highest edition number to insure that you are using the most current map available. The series number appears in the upper right margin, usually next to the edition information. The series number is combined with the sheet number to form the map stock number for requisitioning purposes.

Note. Refer to Vine Grove Map Sheet 3859 IV: the legend and the additional topographic symbols in the left margin of the map. Locate the following topographical symbols and cross-reference each symbol in the legend. Make a free-hand drawing of the symbol in each of the blank spaces.

(2) <u>The identification of topographic symbols is very important to the map user</u>.

(a) 1. ____________ Ohio River with directional arrow for flow of current.
(b) 2. ____________ Indian mound.
(c) 3. ____________ Railroad bridge.
(d) 4. ____________ Railroad tunnel.
(e) 5. ____________ Bench marker 228 and horizontal control point.
(f) 6. ____________ Bullitt and Hardin county boundaries (within Salt River).
(g) 7. ____________ Secondary all-weather, hard surface road.
(h) 8. ____________ Power transmission lines.
(i) 9. ____________ Disappearing stream.
(j) 10. ____________ Spot elevation checked. Note. Always determine if the spot elevation is checked or unchecked. A brown set of figures represents unchecked spot elevation.
(k) 11. ____________ Underground pipeline and underground aqueduct.
(l) 12. ____________ Mine or quarry.
(m) 13. ____________ Light duty, all-weather, hard-to-improve surface road intersection.
(n) 14. ____________ Fair or dry weather, unimproved surface road.
(o) 15. ____________ Secondary all-weather, hard surface road junction.
(p) 16. ____________ Small pond.
(q) 17. ____________ Radio tower (WNCC).
(r) 18. ____________ Road-railroad, graded crossing (same level).
(s) 19. ____________ Train junction.
(t) 20. ____________ School.
(u) 21. ____________ Earthen dam.
(v) 22. ____________ Gunning Cemetery.
(w) 23. ____________ Ford crossing.
(x) 24. ____________ Divided highway with a median strip (31W).
(y) 25. ____________ House and barn.
(z) 26. ____________ Depression.

Correct any errors in your sketch before continuing this subcourse.

b. Practice Exercise—Objective 1.

Identify the following topographic symbols. Symbols are in black unless otherwise specified. Write the answer in the space provided.

(1) : ______________________________

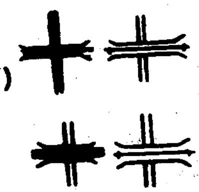
(red)

(2) : ______________________________

(red)

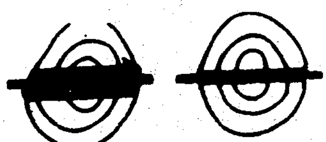
(3) : ______________________________

(4) : ______________________________

(5)  : ______________________________

(red)

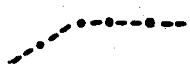
(6) (red) ______________________________

(7)  ______________________________

(red & brown)

(8)  : ______________________________

(blue)

(9)  : ______________________________

(10)  : ______________________________

(11)  : ______________________________

(12)  : ______________________________

(13)  blue) ______________________________

(14)  : ______________________________

(15)  : ______________________________

(16)  : ______________________________

(17)  (blue) : ______________________________

c. Solutions to Practice Exercise - Objective 1.

(1) Road, primary, all-weather, hard surface.
(2) Road, secondary, all-weather, hard surface.
(3) Road, light duty, all-weather, hard or improved surface.
(4) Road, fair or dry weather, unimproved surface.
(5) Overpass or underpass.
(6) Road tunnel.
(7) Cut.
(8) Land cave.
(9) Power transmission lines.
(10) Fort.
(11) Mosque.
(12) Open pit or quarry (coal mine).
(13) Ford.
(14) Horizontal control point ruins.
(15) Monument bench mark at a horizontal control point.
(16) Monument bench mark.
(17) Intermittent lake or pond.

1-2. LEARNING ACTIVITY--OBJECTIVE 2

When you have completed this learning activity, you will be able to identify relief features from contour patterns.

a. Study Reference--Objective 2.

(1) Land forms may be classified into one of the following eight basic terrain features (fig 1-15).

(a) Hilltop.
(b) Valley.
(c) Ridge.
(d) Saddle.
(e) Depression.
(f) Draw.
(g) Spur.
(h) Cliff.

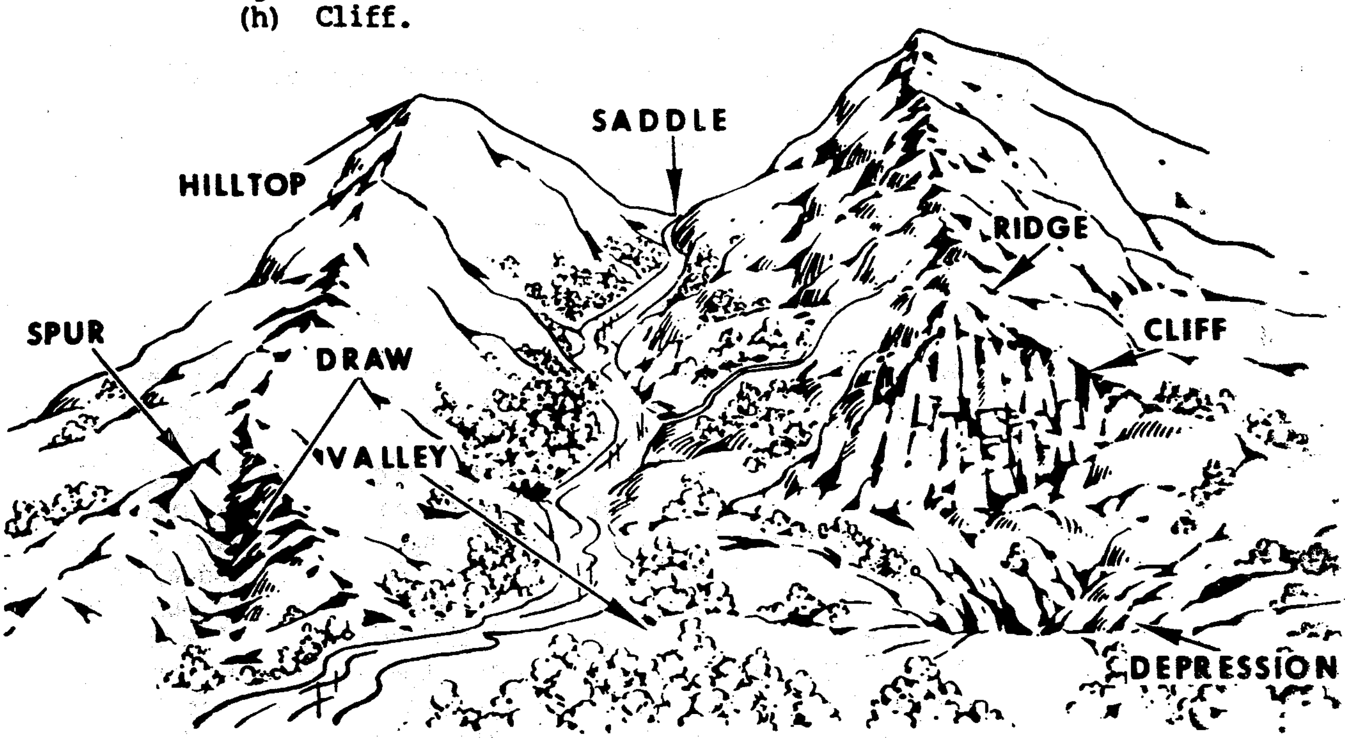


Figure 1-15. Basic terrain features.

(2) The brown contour lines indicate these terrain features on a map. The contour line may be a heavy numbered contour indicating an index contour or it may be a light, intermediate contour line between two index contour lines. There will be intermediate contour lines between every pair of index lines on any United States or North Atlantic Treaty Organization (NATO) map, regardless of contour interval or scale. Sometimes supplementary contours--light, dashed brown lines--are found on standard maps. These contour lines are usually one-half the contour interval. The relationship between

existing contour lines and actual terrain features is illustrated as follows (X indicate your location):

(a) Hill. A point or small area of high ground (fig 1-16). When you are located on a hilltop, the ground slopes down in all directions. On a map, a hilltop is indicated by the last closed contour line (X, Fig 1-16). Also, see example at STAR X on the Vine Grove map sheet.

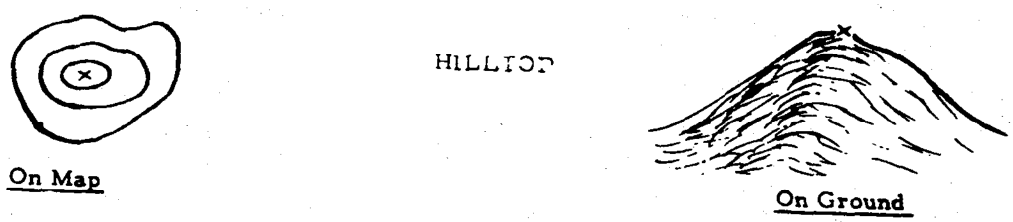


Figure 1-16. Hilltop as shown on the Map and Ground.

(b) Valley. A stream course which has at least a limited extent of reasonably level ground bordered on two sides by high ground (X, fig 1-17). The valley generally has maneuver room within its confines. Contour lines indicating a valley are usually U-shaped, far apart, and tend to parallel a major stream before crossing it. The more gradual the fall of a stream, the farther each contour parallels it. The curve of the contours always points upstream. On a map, these are U- or V-shaped contour lines with the base of the U or V pointing up towards high ground (X, fig 1-17). When you are located in a valley, the ground slopes up in two directions and is level in two directions (see example between STARS A and O on the Vine Grove map).

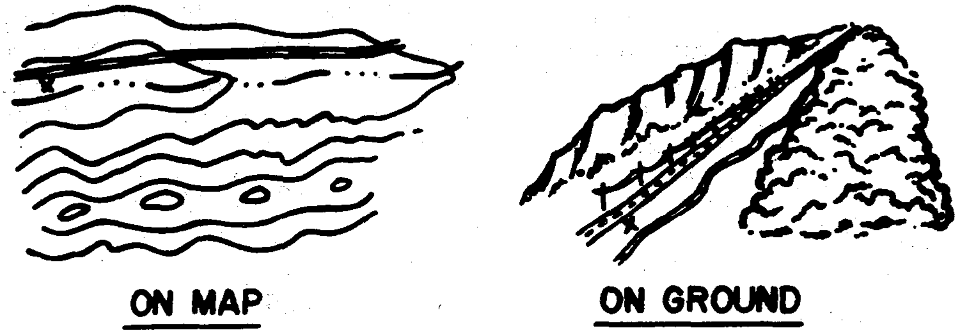


Figure 1-17. Valley.

(c) Ridge. A line of high ground with normally minor variations along its crest. The ridge is not simply a line of hills; all points of the ridge crest are appreciably higher than the ground on both sides of the ridge. When you are located on a ridge, the ground slopes down in two directions and is generally high and fairly level in two directions. Ridges and valleys always alternate (X, fig 1-18). (See example between STARS D and H on the Vine Grove map).

Figure 1-18. Ridge.

(d) Saddle. A dip or low point along the crest of a ridge (X, fig 1-19). A saddle is not necessarily the lower ground between two hill-tops; it may be a dip or break along an otherwise level ridge crest. On the map, the saddle resembles an hourglass or figure eight-shaped contour lines. The points X and Y are both saddles. When you are located in a saddle, there is higher ground in two opposing directions and lower ground in two opposing directions. (See example at STAR T on the Vine Grove map.)

Figure 1-19. Saddle.

(e) Depression. A low point or sinkhole surrounded on all sides by high ground. On the map, a depression is indicated by depression contour lines, with hachures , or "tick" marks pointing toward the lower ground. When you are located in a depression, you will see higher ground in all directions (X, fig 1-20). (See example at STAR G on the Vine Grove map).

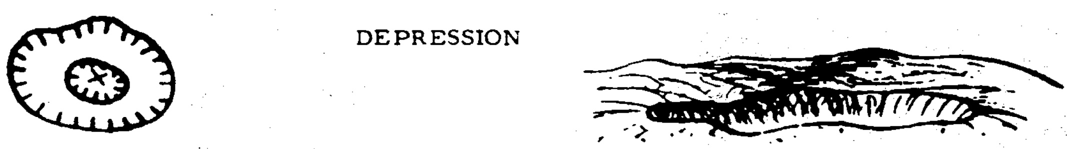


Figure 1-20. Depression.

(f) Draw. A less-developed steam course in which there is essentially no level ground and, therefore, little or no maneuver room within its area. The ground slopes upward on each side and toward the head of the draw. Draws are always found along the side of ridges at right angles to the valley between the ridges. Contours indicating a draw are usually V-shaped with the point of the V pointing towards the head of the draw (fig 1-21). The opening of the V draws away from low ground. On the ground, if you are in a draw the ground will slope up in three directions and down in one direction (fig 1-22). (See example between STAR L and R on the Vine Grove map).

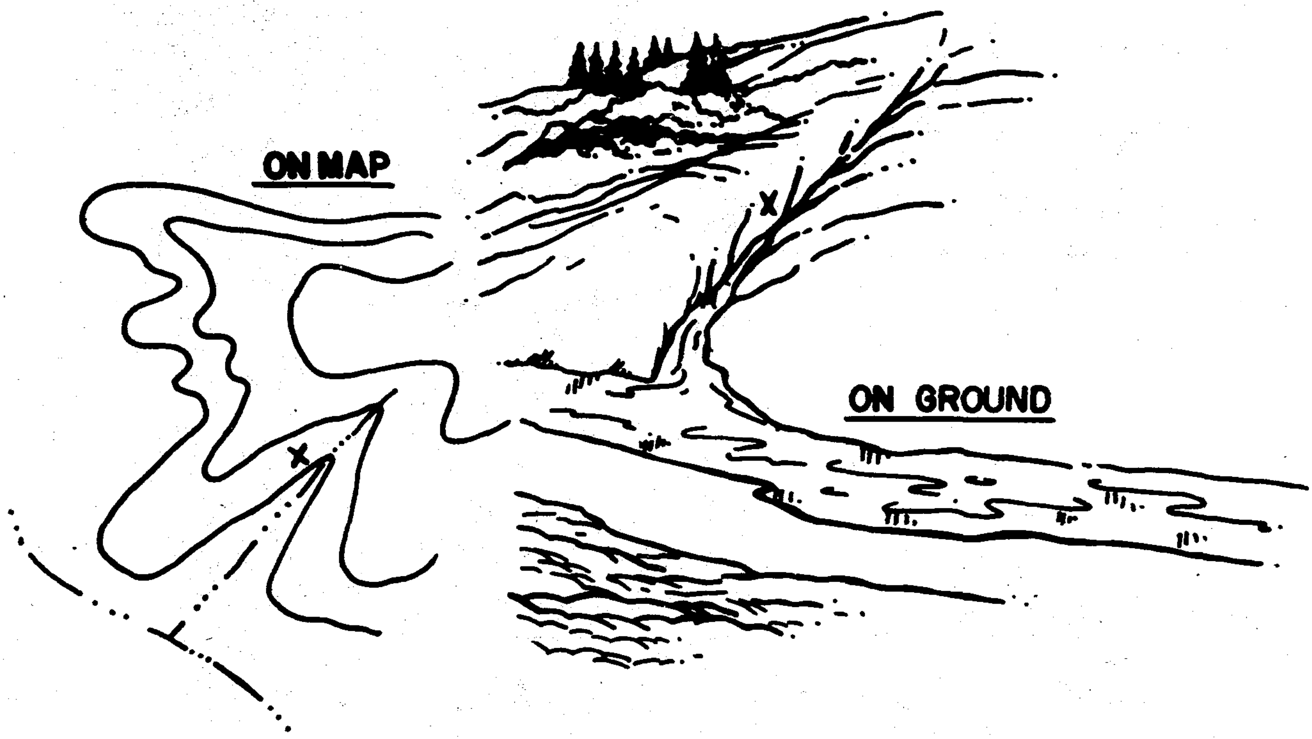


Figure 1-21. Draw.

(g) Spur. A usually short, continuously sloping line of higher ground jutting out from the side of a ridge (fig 1-22). Spur contours bulge AWAY from high and toward low ground. A spur is often formed by two roughly parallel streams cutting draws down the side of a ridge. When you are on a spur, the ground slopes down in three directions and up in one direction (fig 1-22). (See example between STARS M and S on the Vine Grove map.)

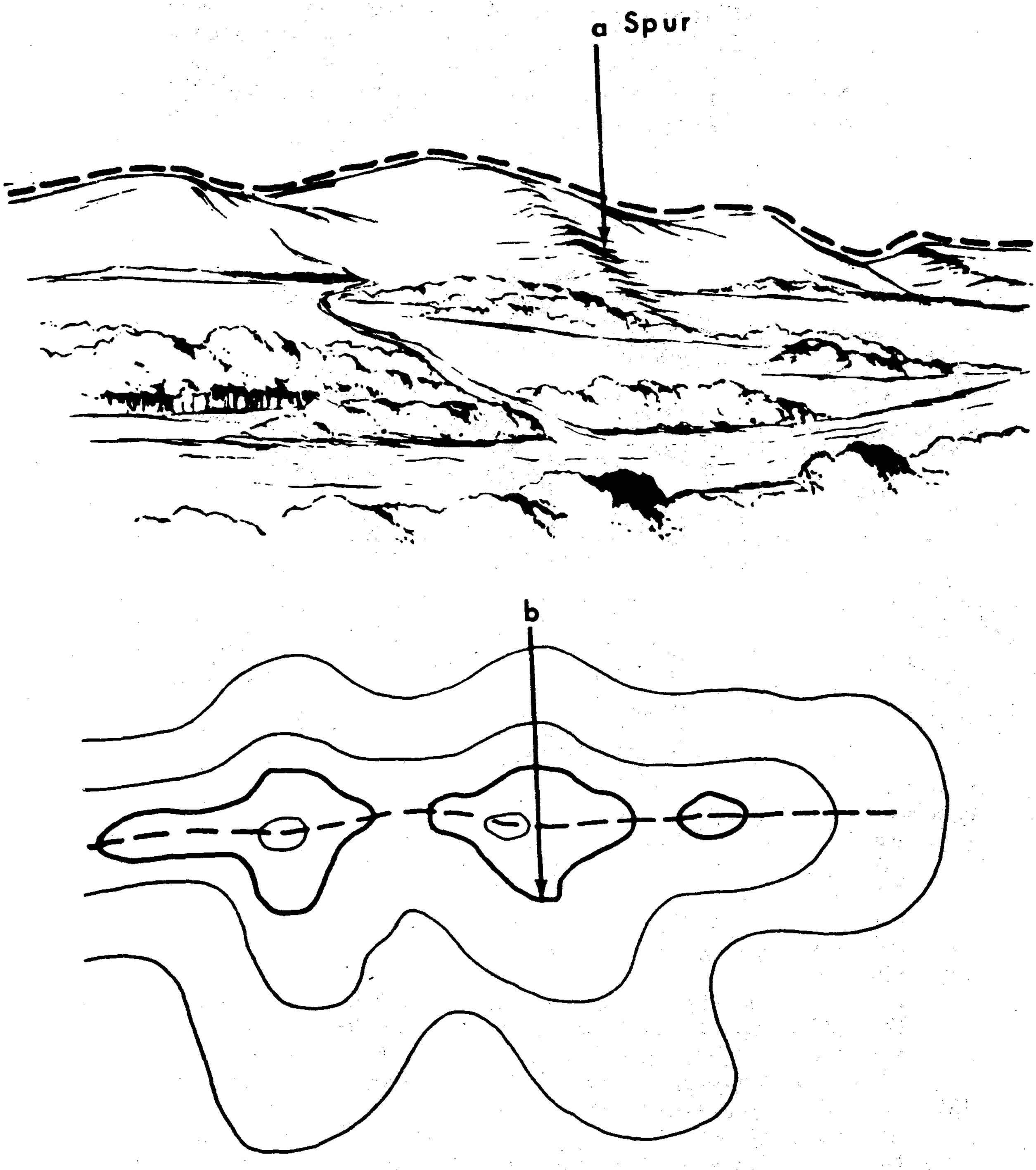


Figure 1-22. Spur.

(h) Cliff. A vertical or near-vertical slope (fig 1-23). When a slope is so steep that it cannot be shown at the contour interval without the contour lines meeting, it is sometimes shown by a ticked "carrying" contour or contours. The ticks always point toward lower ground. Usually, the map maker will just "pinch-out" one or more intermediate contour lines. (See example inside the letter O in the lower right corner of the Vine Grove map.)

Figure 1-23. Cliff.

b. Practice Exercise--Objective 2.

(1) Point features (Hill, Saddle, Depression, Cliff).
   (a) What feature is at the top of Star Q?
   (b) What feature is at Star K?
   (c) What feature is at Star L?
   (d) What feature is at Star J?

(2) Linear features (Ridge, Spur, Valley, Draw).
   (a) What feature is between Stars P and E?
   (b) What feature is between Stars F and V?
   (c) What feature is between Stars S and M?
   (d) What feature is between Stars E and P?

(3) Mixed features (All 8 relief features).
   (a) What feature is between Stars A and N?
   (b) What feature is at Star C?
   (c) What feature is between Stars D and L?
   (d) What feature is at Star S?

c. <u>Solutions to Practice Exercise--Objective 2.</u>

(1) Point features.

(a) Saddle.

(b) Hill.

(c) Saddle.

(d) Depression.

(2) Linear features.

(a) Draw.

(b) Ridge.

(c) Spur.

(d) Draw.

(3) Mixed features.

(a) Valley or Draw.

(b) Hill.

(c) Ridge.

(d) Hill.

1-3. LEARNING ACTIVITY--OBJECTIVE 3

When you have completed this learning activity, you will be able to explain military grids and the US Military Grid Reference System.

a. <u>Study Reference--Objective 3.</u>

(1) <u>Military Grids.</u> An examination of a Transverse Mercator Projection (fig 1-24) used for large-scale military maps, shows that most lines of latitude and longitude are curved lines. The quadrangles formed by the intersection of these curved parallels and meridians are of different sizes and shapes, complicating the location of points and the measurement of directions. To facilitate these essential operations, a rectangular grid is superimposed upon the projection. This grid (a series of straight lines intersecting at right angles) furnishes the map reader with a system of squares similar to the block system of most city streets. The dimensions and orientation of different types of grids vary, but these three properties are common to all military grid systems:

- They are true rectangular grids.
- They are superimposed on all geographic projections.
- They permit linear and angular measurements.

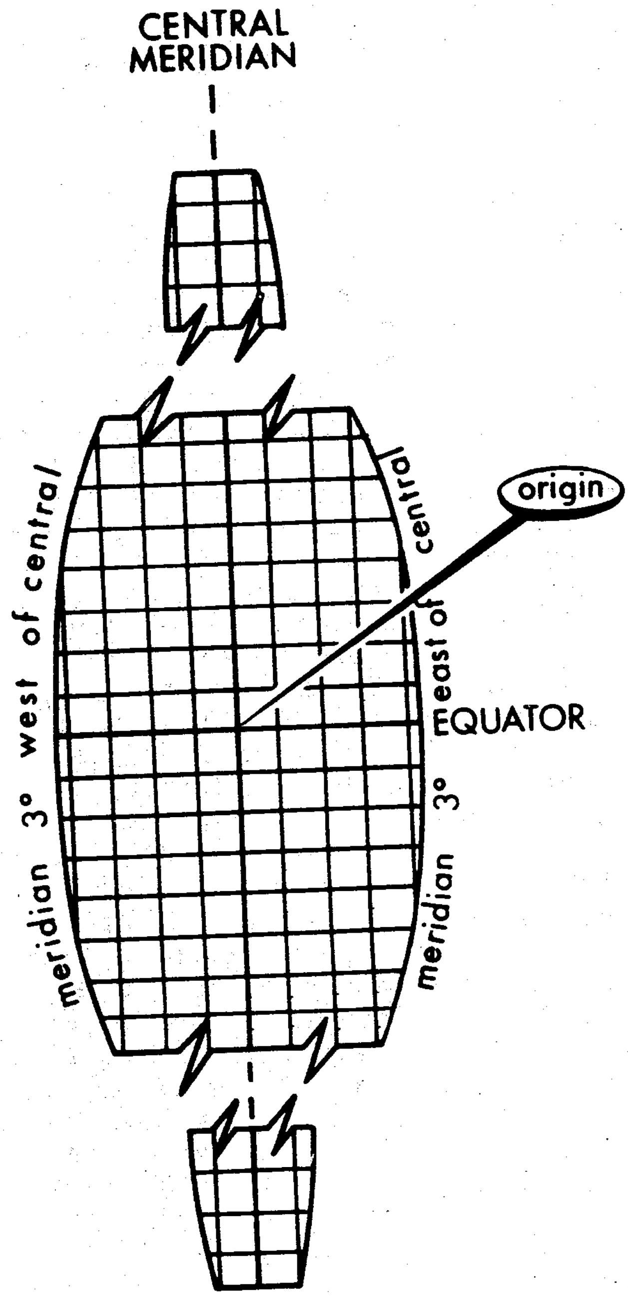


Figure 1-24. A UTM grid zone.

(a) Universal Transverse Mercator Grid. The Universal Transverse Mercator (UTM) Grid has been designed to cover that part of the world between lat 84°N and lat 80°S and applies to most of the world, except the Arctic and Antarctic. As its name implies, it is imposed on the Transverse Mercator Projection. Each of the 60 zones (6° wide) into which the globe is divided for the grid originates at the intersection of its central meridian and the equator (fig 1-25). The grid is identical in all 60 zones. Base values (in meters) are assigned to the central meridian and the equator. The grid lines are drawn at regular intervals parallel to these two base lines. With each grid line assigned a value denoting its distance from the origin, the problem of locating any point becomes progressively easier. Normally it would seem logical to assign a value of zero to the two base lines and measure outward from them. This, however, would require either that directions--N, S, E, or W--be always given with distances, or that all points south of the equator or west of the central meridian have negative values. This inconvenience is eliminated by assigned "false values" to the base lines, resulting in positive values for all points within each zone. Distances are always measured RIGHT and UP (east and north as the reader faces the map). The assigned values are called "false easting" and "false northing." The false easting value for each central meridian is 500,000 meters; the false northing value for the equator is 0 meter(s) when measuring in the Northern Hemisphere and 10,000,000 meters when measuring in the Southern Hemisphere (fig 1-26). The use of the UTM Grid for point designation will be discussed in detail in (2), The US Army Military Grid Reference System.

(b) Universal Polar Stereographic Grid. The rectangular grid imposed on the areas represented by the Polar Stereographic Projection is called the Universal Polar Stereographic (UPS) Grid.

1 North polar area. The origin of the UPS Grid applied to the north polar area is the North Pole. The "north-south" base line is the line formed by the 0° and 180° meridians; the "east-west" base line is the line formed by the two 90° meridians. The false coordinates of the origin are 2,000,000 meters east and 2,000,000 meters north (fig 1-27).

2 South polar area. The origin of the UPS Grid in the south polar area is the South Pole; the base lines and false coordinates of the origin are similar to those of the north polar area (fig 1-27).

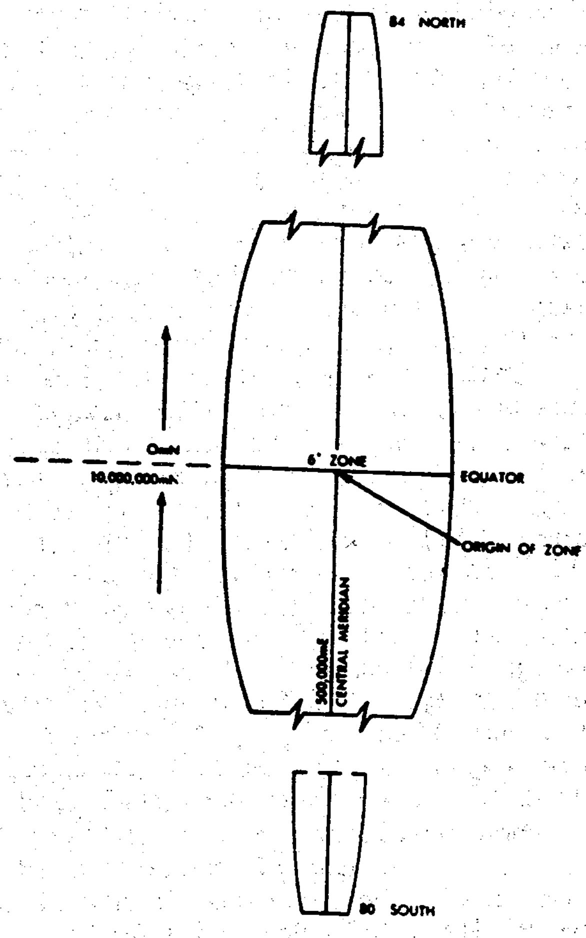


Figure 1-25. False easting and northing for a grid zone.

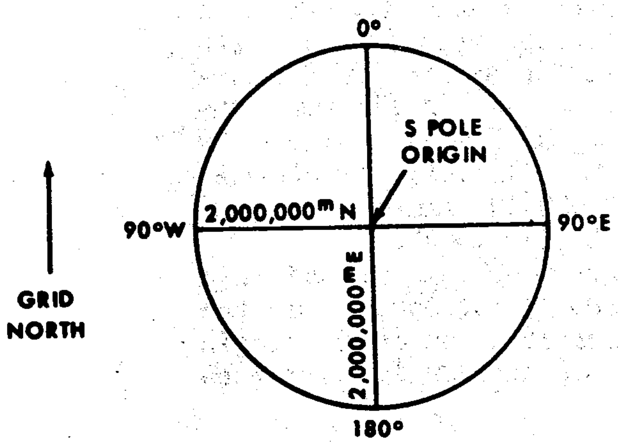


Figure 1-26. False easting and northing for UPS Grid (South Pole).

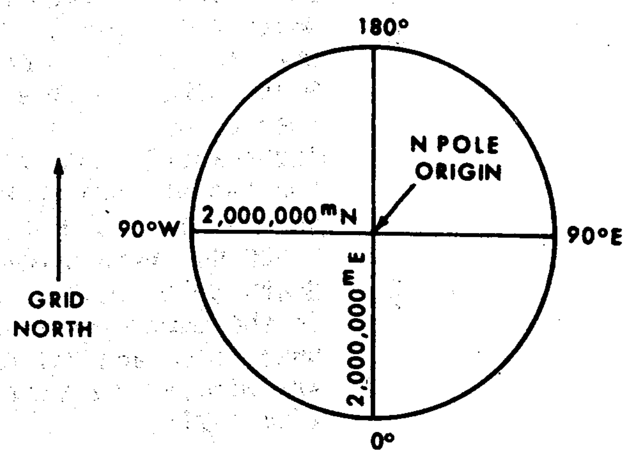


Figure 1-27. False easting and northing for UPS Grid (North Pole).

(2) US Military Grid Reference System.

(a) The United States Army Military Grid Reference System is designated for use with the UTM and UPS Grids. The coordinate values of points in these grids could contain as many as 15 digits, if numerals alone were used. The US Army Military Grid Reference System reduces the length of written coordinates by substituting single letters for several numbers. Using the UTM and the UPS grids, it is possible for the location of a point (identified by numbers alone) to be in many different places on the earth's surface. With the use of the US Army Military Grid Reference System, though, there is no chance for a point to be identified at more than one place on the earth's surface. This becomes very important in this age of possible global warfare. In this system, the world is divided into 60 grid zones which are large, regularly-shaped geographic areas, each of which is given a unique identification called the grid zone designation. These are covered by a pattern of 100,000-meter squares, based on the grid covering the area. Each square is identified by two letters called the 100,000-meter square identification. This identification is unique within the area covered by the grid zone designation. Numerical references within the 100,000-meter square are given to the desired accuracy in terms of the easting (E) and northing (N) grid coordinates for the point.

1 Grid Zone Designation.

a UTM Grid. The first major breakdown is the division of each zone into areas 6^{o} x 8^{o} and 6^{o} x 12^{o}. For the Transverse Mercator Projection, the earth's surface between 80^{o}S and 84^{o}N is divided into 60 N-S zones each 6^{o} wide. These zones are numbered from west to east, 1 through 60, starting at the 180^{o} meridian. This surface is divided into 20 east-west rows, each 8^{o} high, and 1 additional row at the extreme north which is 12^{o} high. These rows are then lettered from south to north, C through X (I and O omitted to avoid confusion with numerals). Any 6^{o} x 8^{o} zone or 6^{o} x 12^{o} zone can then be identified by giving the number and letter of the grid zone and row in which it lies. These are read RIGHT and UP, so the number is always written before the letter. This combination of zone number and row letter constitutes the grid zone designation. Fort Knox lies in zone 16 and row S, or in grid zone designation 16S (fig 1-28).

b UPS Grid. The remaining letters of the alphabet, A, B, Y, and Z, are used for the UPS Grids. Each polar area is divided into two zones separated by the 0^{o}-180^{o} meridian. In the south polar area, the letter A is the grid zone designation for the area west of the 0^{o}-180^{o} meridian and B for the area to the east. In the north polar area, Y is the grid zone designation for the western area and Z for the eastern (fig 1-29).

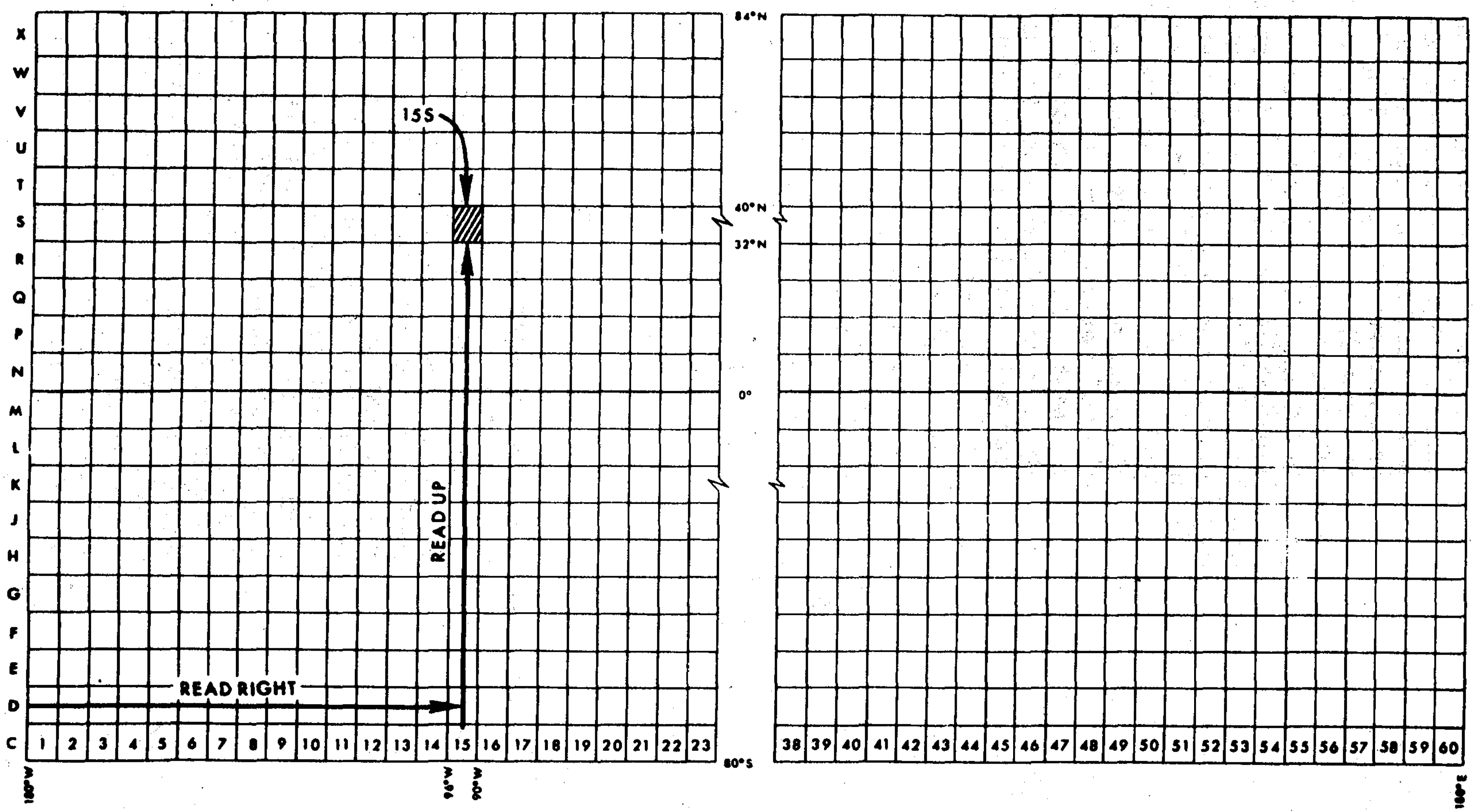


Figure 1-28. Grid zone designation

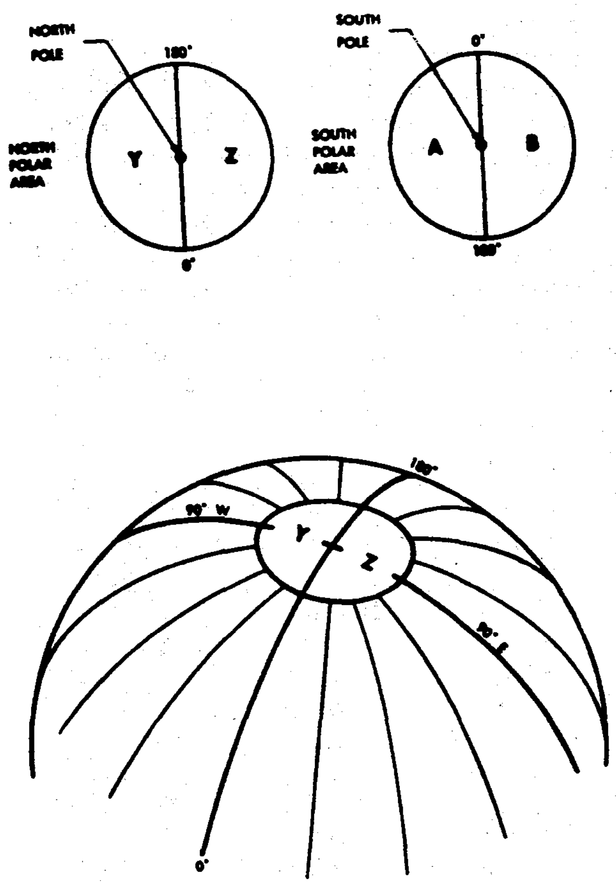


Figure 1-29. Grid zone designation for UPS Grid.

2 100,000-Meter Square. Between 84° north and 80° south, each 6° x 8° or 6° x 12° zone is covered by 100,000-meter squares identified by the combination of two letters. The first letter is the column designation; the second letter is the row designation (fig 1-30). The north and south polar areas are also divided into the 100,000-meter squares by columns and rows. The system is designed to place like-lettered squares as far apart as possible. A detailed discussion of the arrangement of letters which identify the columns and rows of 100,000-meter squares is beyond the scope of this subcourse; TM 5-241-1 gives a description of the system. The 100,000-meter square

identification letters for each sheet are shown in the sheet miniature which is a part of the grid reference box in the lower margin of the map.

3 Military Grid Reference. We have now divided the earth's surface into $6^{\circ} \times 8^{\circ}$ quadrangles and covered these with 100,000-meter squares. The military grid reference of a point consists of the numbers and letters indicating in which of these areas the point lies, plus coordinates locating the point to the desired precision within the 100,000-meter square. Having learned the essentials of the grid zone designation and the 100,000-meter square identification, it remains but to see how the point coordinates tie in with these larger areas.

a Grid lines. The regularly spaced lines that make up the UTM and UPS Grids on any large-scale map are divisions of the 100,000-meter square; the lines are spaced at 10,000- or 1,000-meter intervals. Each of these lines is labeled at both ends with its false easting or false northing value (showing its relation to the origin of the zone). For the 1,000-meter grid, except for the values labeling the first grid line in each direction from the southwest corner of the sheet, the last three digits (000) of the value are omitted. Two digits of the value are printed in large type; these same two digits appear at intervals along the grid line on the map face. They are called the principal digits and represent the 10,000 and 1,000 digits of the grid value; they are of major importance to the map reader because they are numbers he will use most often for referencing points. The smaller digits complete the full false coordinates of the grid lines, but they are rarely used for point designation (fig 1-31). On sheets whose grid line spacing is 10,000 meters, only one principal digit is shown, representing the 10,000 digit of the grid value.

Example:

The first grid line north of the southwest corner of the Vine Grove map is labeled 4170000m.N. This means its false northing (distance north of the equator) is 4,170,000 meters. The principal digits, 70, identify the line for referencing points in the northerly direction. Likewise, the first grid line east of the southwest corner is labeled 589000m.E. This is because the central meridian has a value of 500,000 m.E, and this grid line is 89,000 meters west of the central meridian. The principal digits, 89, identify the line for referencing points in the easterly direction.

b Grid coordinate scale. A grid coordinate scale protractor (fig 1-33) divides a grid square more accurately than estimation, and the results are more consistent. Also, this scale has been designed for the express purpose of plotting grid coordinates; it is much faster than using an engineer scale and presents less chance of error.

(1) The 1:25,000/1:250,000 scale (lower right in figure) subdivides the 1,000-meter (or 10,000 meter) grid square into 10 major subdivisions, each equal to 100 meters (or 1,000 meters). Each 100-meter block has five graduations, each equal to 20 meters (or 200 meters). Points falling between the two graduations can be read accurately to 10 meters (or 1000 meters), this value being the fourth and eight digits of the coordinates.

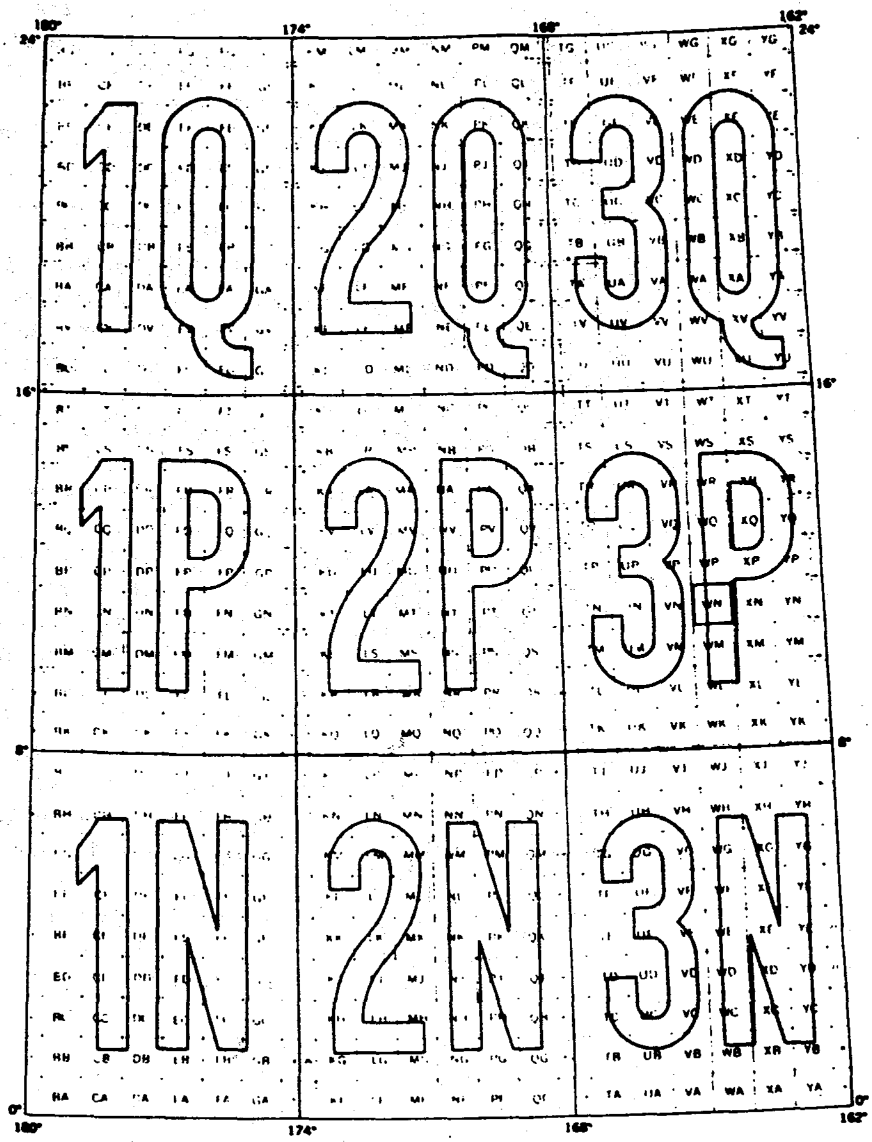


Figure 1-30. 100,000-meter square identification.

(2) The 1:50,000 scale (upper left in figure) subdivides the 1,000-meter grid square into 10 major subdivisions, each equal to 100 meters. Each 100-meter block is then divided in half. Points falling between these graduations must be estimated

to the nearest 10 meters for the fourth and eighth digits of the coordinates.

(3) To use a coordinate scale protractor for determination of coordinates, place the protractor with the zeros of the scale at the lower left corner of the grid square. Keeping the scale on the lower horizontal grid line, slide it to the right until the point for which coordinates are desired touches the edge of the scale. When reading coordinates, examine the two sides of the coordinate scale to insure that the horizontal scale is aligned with the east-west grid line, and the vertical scale is parallel with the north-south grid line (fig 1-32 and 1-34).

c Point designation. The designation of a point is based on the military principle "Read RIGHT then UP." The precision desired determines the number of digits to be read beyond the principal digits. It should be impressed upon the reader that the term "grid coordinate" often includes both the 100,000-meter square identification and the desired number of digits. In many instances, it is a tactical requirement that the 100,000-meter square identification be included in any point designation.

(1) Reading RIGHT-UP (fig 1-34), coordinates 1484 locate the 1000-meter grid square in which point X is located. The next square to the right would be 1584; the next square up would be 1585; etc.

(2) To locate the point to the nearest 100 meters, estimate the tenths of the grid square from grid line to point in the same order (RIGHT-UP). Give complete coordinate RIGHT, then complete coordinate UP. This point is about 2 tenths of a grid square right and about 1 tenth up; coordinates to the nearest 100 meters are 142841. For greater accuracy, use

the coordinate scale and protractor (fig 1-32).

(3) Artillery requirements usually call for location of the target within at least 100 meters (about 300 feet). To

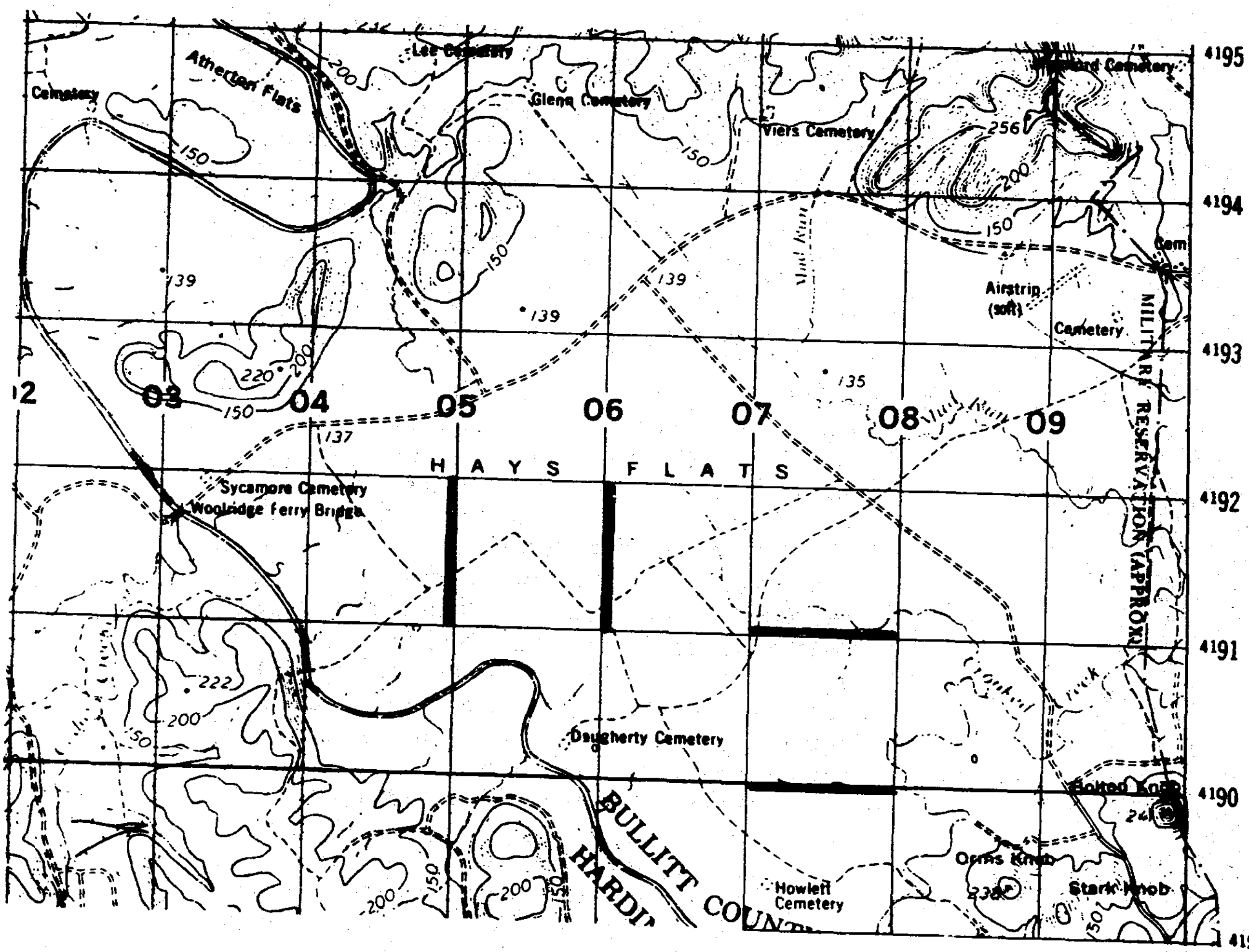


Figure 1-31. Grid lines.

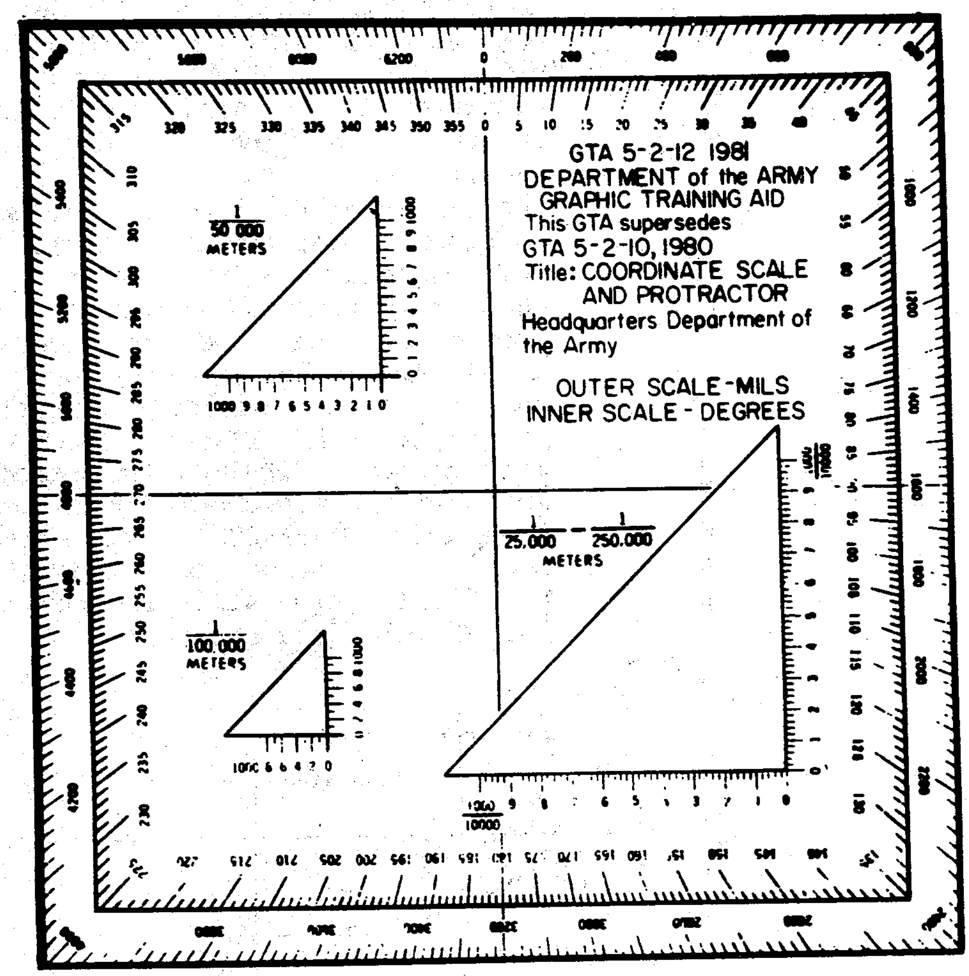


Figure 1-32. Coordinate scale protractor.

locate the point to the nearest 10 meters, plus or minus 30 meters (due to map accuracy limitations), use the coordinate scale protractor to measure the hundredths of a grid square RIGHT and UP from grid line to point. This point is 17 hundredths right and 9 hundredths up; coordinates to the nearest 10 meters are 14178409 (always prefix with zero if the hundredths reading is less than 10).

(4) On maps of very large scales and under special conditions, it may be desirable to locate a point within one meter. This is done by measuring the thousandths of a grid interval from line to point (fig 1-33).

(5) The precision of a point reference is shown by the number of digits in the coordinates—the more digits, the more precise the location. The number of digits and the accuracy attained remain the same on all tactical maps, regardless of scale. In figure 1-34: 1484-a 1,000-meter grid square, 142841-to the nearest 100 meters, 14178409-to the nearest 10 meters, 1416884087-to the nearest meter. On medium scale maps, a two-digit grid will locate one 10,000-meter grid square.

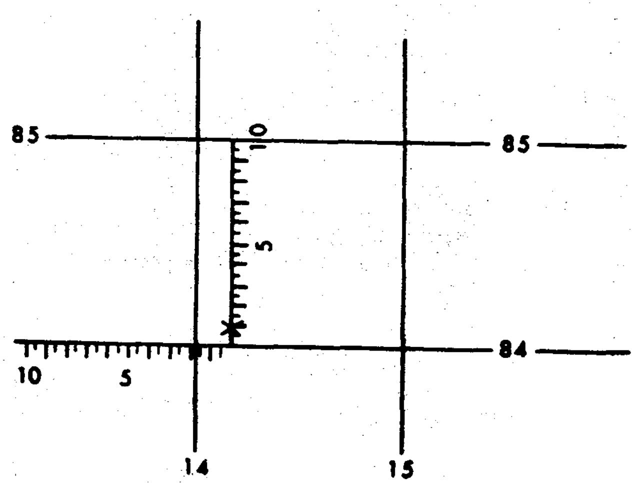


Figure 1-33. Proper placement of a coordinate scale protractor on a grid to read coordinates of a point.

(6) If a scale is not available that exactly divides the side of the grid square in tenths or hundredths, these divisions may be made by slanting the scale until it fits the interval between grid lines.

(7) Coordinates are written as one continuous number without spaces, parentheses, dashes, or decimal points. Whoever is to use the written coordinates must know where to make the split between the RIGHT reading and the UP reading; for this reason, the coordinates of the point within the 100,000-meter square must always contain an even number of digits.

(b) Grid Line Numbering. Each vertical and horizontal grid line on a map is identified by two digits (fig 1-34). They are printed in large (bold) type at each end of the grid lines and within the face of the map itself (refer to the Vine Grove map). These large digits are called <u>principle digits</u>. These digits are of major importance to the map reader, since these are numbers he will use in reference points using the Military Grid Reference System. The numbers in smaller type ((2), fig 1-34) indicate the distance of the grid original grid (used in UTM but not in point location by grid reference).

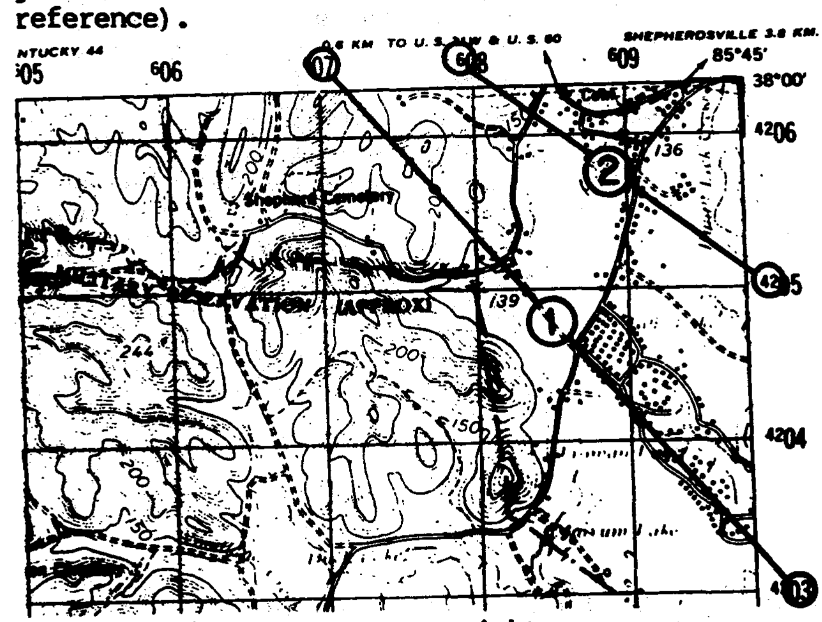


Figure 1-34. Grid system (upper right corner Vine Grove map).

(c) Use of the Coordinate Scale Protractor.

Step 1: Remember, a grid is a network of evenly spaced horizontal and vertical lines. Look at figure 1-31 and locate the vertical and horizontal grid reference lines; look at the Vine Grove map and locate the principle digit (vertical line) 07; locate the principle digit (horizontal line) 04.

Step 2: Place the point of your pencil at the intersection of principle grids 07 and 04, which will be the lower left of the Grid Square. Remember, read RIGHT and UP. The hilltop (lower left) in grid square 0704 is now located, or point determined to within 1,000 meters.

Step 3: Remove the coordinate scale protractor (GTA 5-2-12, 81) from the packaged materials shipped with this subcourse (fig 1-32). Hold the coordinate scale protractor in your hands (right thumb at 90°, 1,600 mils, east, and the left thumb at 270°, 4,800 mils, west) and north or 0 on both scales will be pointing UP. As an additional check, read the words "Department of the Army Graphic Training Aid" in the upper right corner of the coordinate scale protractor, and the representative fraction 1:50,000 meters in the left corner of the protractor. Always use the protractor with 0 "UP" so the text can be read.

Step 4: Place the coordinate scale protractor on the map; the 1:50,000 scale to the left will appear as a backward L. Place the two intersecting 0 lines (extension of the L) on the intersection of the principle grid 0704 (fig 1-35). You have now matched the coordinate scale with the grid lines.

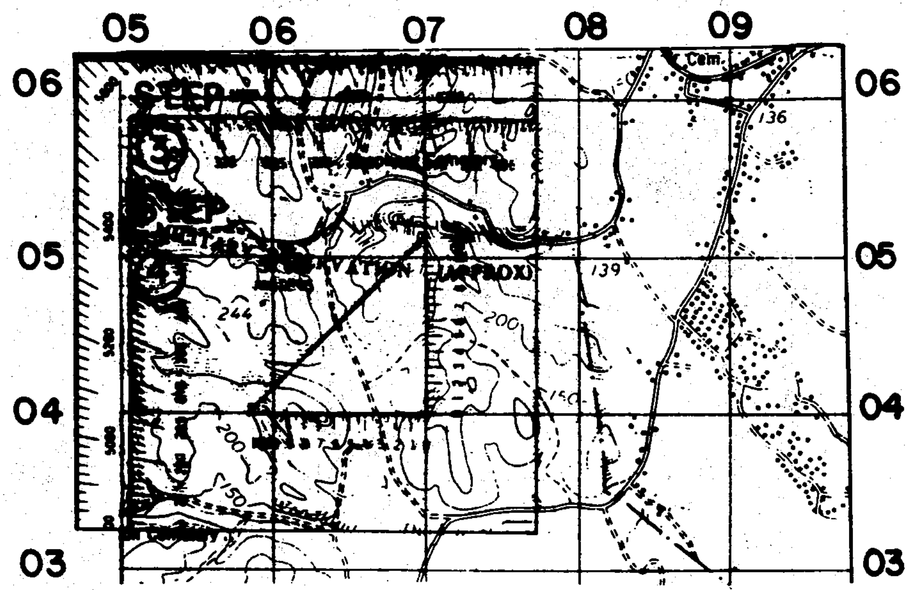


Figure 1-35. Military grids (cont).

Step 5: To locate the point (hill enclosed contour), slide the coordinate scale protractor to the right along the EW grid (04) until the vertical part of the backward L (fig 1-41) is center of mass of the hilltop. Read RIGHT on the coordinate scale; as the scale is moved away from grid 07, the coordinate scale measured the distance. Determine where grid line 07 falls on the coordinate scale protractor. Read 3. Write 073, because you measured the distance from the NS grid line. Now, look at the 04 EW grid and read UP. Remembering the military principle of RIGHT and UP from the 0 on the coordinate scale and protractor, count the numerals to the center of mass of the hilltop. Read 2. Since you are reading UP from the 04 grid, write 042. The six-digit grid reference to the point (hilltop) is 073042, which locates the point to within 100 meters (fig 1-36).

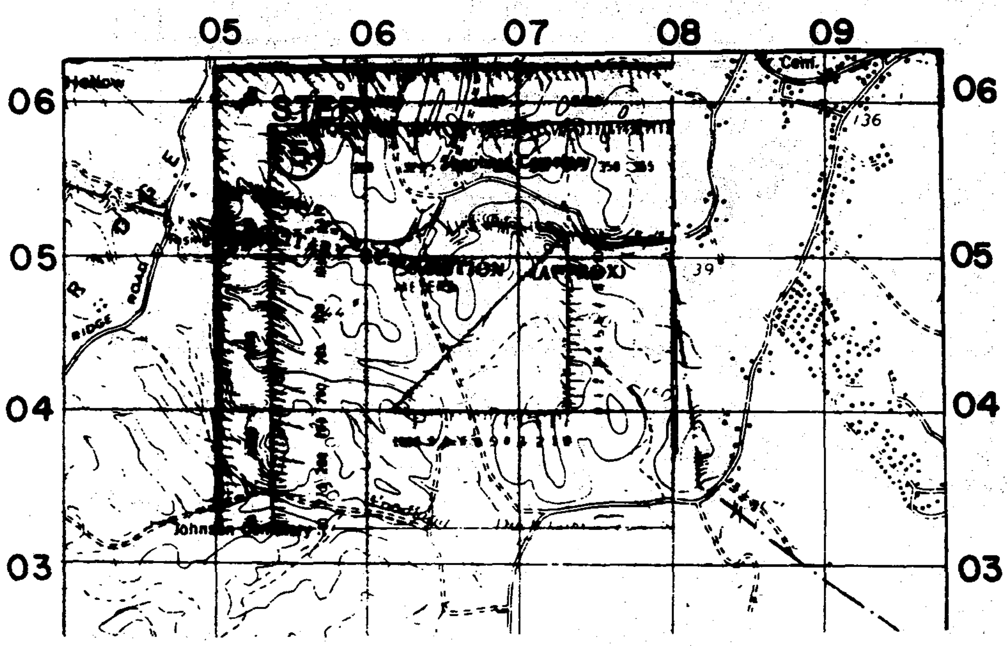


Figure 1-36. Six-digit coordinate.

Some tactical situations require greater degrees of accuracy or point designation than 100 meters; in such a case, measure to the nearest 10 meters using eight-digit coordinates (fig 1-37).

Step 6: Look closely at the coordinate scale and protractor as the 3 intersects the NS grid line. The measurement is slightly greater than 3. Therefore, a more precise measurement must be interpolated (estimated). To interpolate, examine the coordinate scale protractor. The distance between the increments of 1 to 10 is 10 meters. Again, look at the position of the 3 as it intersects the 07 NS grid line and read 1. The one is an estimate. Read 0731 because you have measured 073; it now becomes necessary to add 1. Examine the coordinate scale protractor as it is positioned on the EW grid line; read up to 2. Upon close examination, you will find that the center of mass is still centered on the 2. Add 0 for "place" value to complete the eight- digit coordinate ((1)(2), fig 1-37).

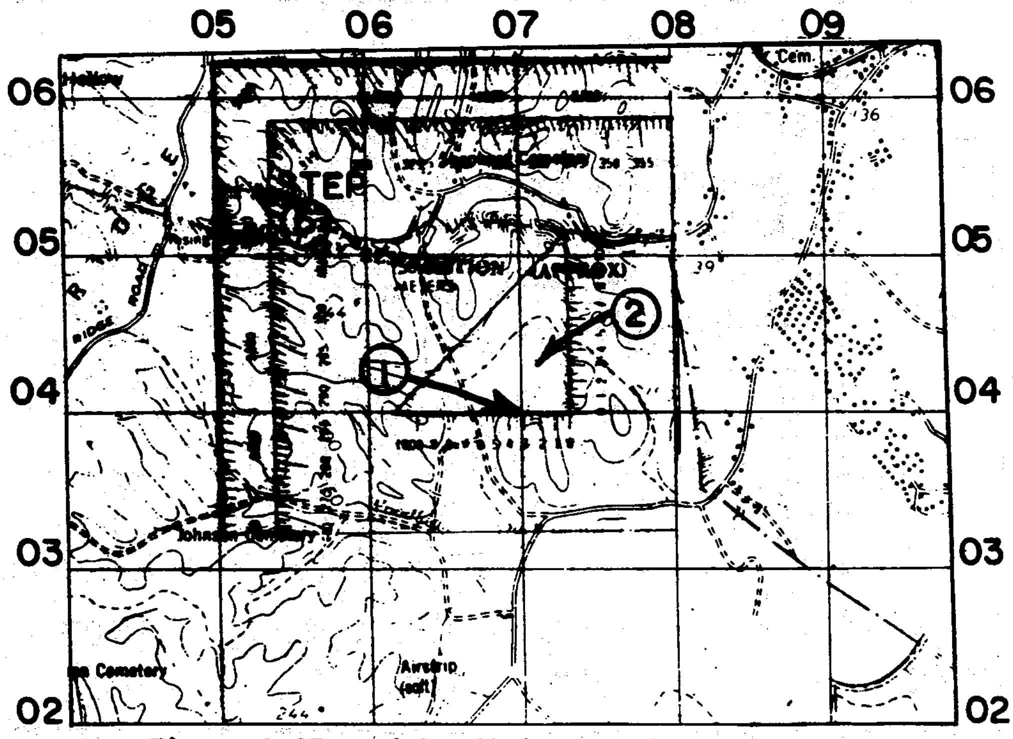


Figure 1-37. Eight-digit coordinates.

(d) Reading Grid Coordinates. The point located by reference will always have an even count of numerals in the grid reference (i.e., 073042 has a count of 6; 0731 and 0420 have 4). To determine the principle digits of any set of grid references, simply split the set into two equal parts. The first two numerals are the north-south grid principle digits. Each number thereafter in the first half is a measured grid obtained from a coordinate scale protractor reading. The second half of numerals are EW grid references, with the first two numerals representing the EW principle digits. The second set of numerals are the same as above, except the coordinate scale measurements are read UP from the east-west grid (fig 1-38).

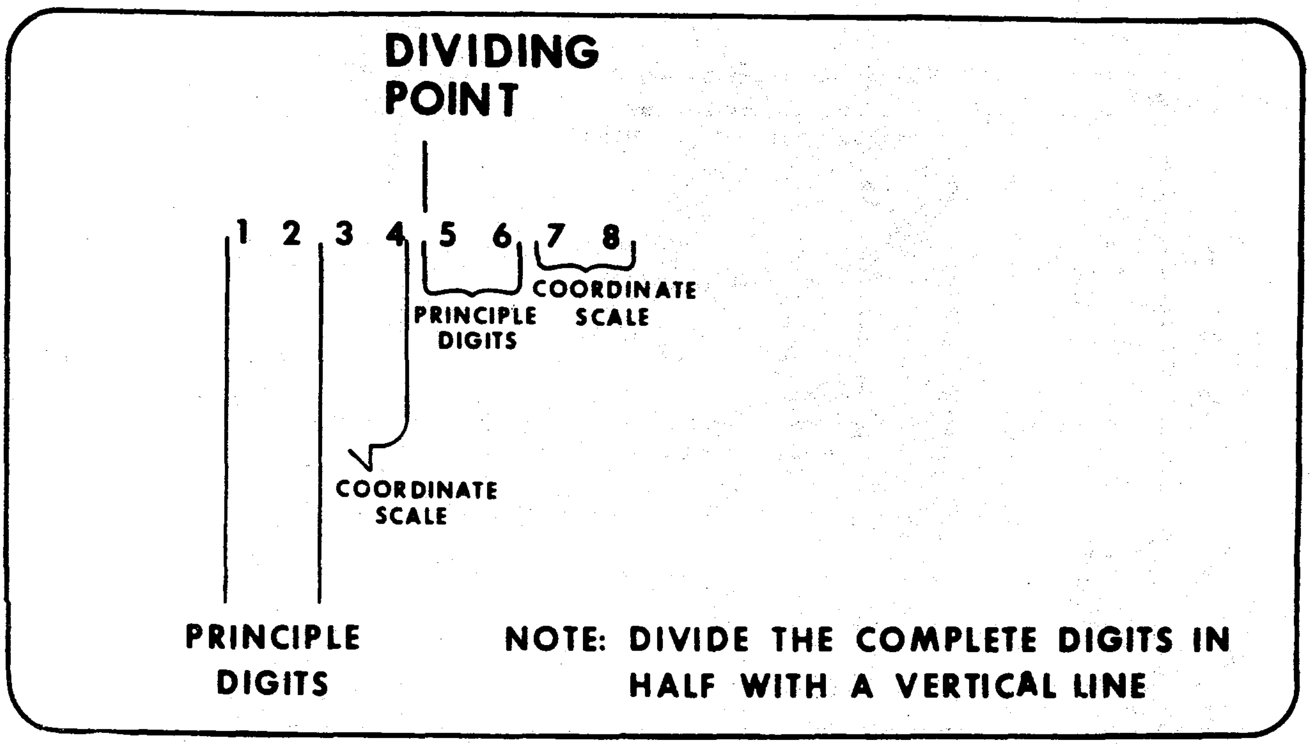


Figure 1-38. Reading coordinates.

(e) Complete Grid Reference. A complete grid reference of a point may include the grid zone designation, but will always include the 100,000-meter designation, and the exact location of the point (fig 1-39).

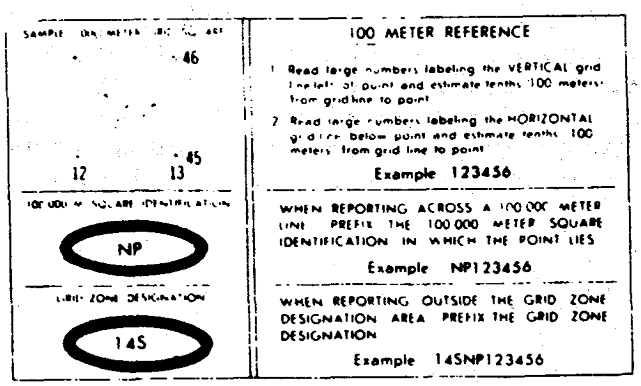


Figure 1-39. Grid reference box.

Example: Determine the grid reference for X the sample point in fig 1-39.

Answer: NP123456.

Solution: The complete reference must include the 100,000-meter grid square NP, and the sample point location, 123456.

(f) Abbreviated Grid References. Some military units use an abbreviated grid reference which allows the map reader to dispense with the grid zone designation. A majority of units will require the 100,000-meter grid zone designation to be written when others must use the information and practice during tactical operations with integrated map training. This subcourse will require the two-lettered, 100,000-meter grid zone designation for all practical exercises, solutions, and examinations.

b. Practice Exercise—Objective 3.

(1) The Military Grid Reference System is designed to be used with the ____________ ____________ ____________ and the ____________ ____________ ____________ grids.

(2) How is the Military Grid Reference System used in conjunction with the Universal Transverse Mercator Grid system? ____

____

(3) What section of the globe is covered by the Universal Transverse Mercator Grid System? ____________________

____

(4) What area(s) of the world does the Universal Polar Sterographic Grid System cover? ____________________

____

(5) Explain grid zone designations and 100,000-meter square identification? ______________________________

____

____

(6) Name the 100,000-meter square(s) that appear on the Vine Grove map sheet. ______________________________
Note. Refer to figure 1-39.

(7) What do the circled areas in figure 1-39 represent?

______________________________.

(8) The distance (fig 1-31) from east to west between the two grid lines in the shaded area is __________ meters?

(9) The vertical (north-south) grid lines are referred to as false __________________. The horizontal grid lines (east-west) are referred to as false __________________.

(10) Determine the map distance (in thousands of meters) from north to south on figure 1-38 (shaded area): __________.

(11) Write all principle digits for EW grid lines in figure fig 1-40, Vine Grove map sheet: ______________________________

(12) Write all principle digits for the north-south grid lines in figure 1-40, Vine Grove map sheet: ______________

____

(13) Refer to the Vine Grove map sheet. What is the number of the principle digit (north-south) grid line for the bench marker (221) in grid square ES0091? ______________

(14) What is the number of the principle digit(s) (east-west) grid line for the bench marker (221) in grid square ES 0091?______________________________

(15) Complete the following requirements, using the Vine Grove map 1:50,000 special overprint. Write your answer in the space provided.

(a) Requirement: Determine the grid square in which each of the following is located:

1 Indian mound, item 2. ____________________

2 Pond, item 16. ____________________

3 Road junction, item 15. ____________________

4 Ford, item 23. ____________________

5 Cemetery, item 22. ____________________

(b) REQUIREMENT: Determine the identity of each of the following:

6 Name of the cemetery in grid square ET 9403. ____________________

7 Name of the church in grid square ES 9089. ____________________

8 Name of the lake in grid square ES 9484. ____________________

9 Name of the cemetery in grid square ES 9689. ____________________

10 Elevation at the bench mark in grid square ES 9400. ____________________

(c) REQUIREMENT: Determine the six-digit coordinates of the following:

11 Indian mound, item 2. ____________________

12 Pond, item 16. ____________________

13 Road junction, item 15. ____________________

14 Ford, item 23. ____________________

15 Cemetery, item 22. ____________________

(d) **REQUIREMENT:** Identify the object at each of the following six-digit grid readings:

<u>16</u> At ES 962964 ________________

<u>17</u> At ES 935901 ________________

<u>18</u> At ES 879009 ________________

<u>19</u> At ES 945825 ________________

<u>20</u> At ES 952853 ________________

c. Solutions to Practice Exercise--Objective 3.

(1) The Military Grid Reference System is designated to be used with the Universal Transverse Mercator and the Universal Polar Stereographic Grids.

(2) The United States Army Military Grid Reference System reduces the length of written coordinates by substituting single letters for several numbers.

(3) The Mercator Projection covers the earth's surface between 80° south 84° north latitudes.

(4) The Universal Polar Stereographic System is used in the polar area from 80° south to the south pole and from 84° north to the north pole.

(5) The world is divided into 60 grid zones. These are large, regularly shaped geographic areas, each of which is given a unique identification called the grid zone designation. These zones are covered by 100,000-meter grid squares identified by two letters.

(6) There are four sections of the 100,000-meter square for Vine Grove. Those squares are identified as ET, FT, ES, and FS.

(7) The circled areas would represent the grid zone and the 100,000 M square for the Vine Grove map sheet. 16S is the grid zone designation for the Vine Grove map sheet.

(8) The distance in figure 1-38 from west to east is 1,000 meters.

(9) Vertical (north-south) grid lines are referred to as false eastings. Horizontal grid lines (east-west) are referred to as false northings.

(10) The map distance from north to south on figure 1-38 is 1,000 meters.

(11) The principle digits for EW grid lines are 03, 04, 05, and 06.

(12) The principle digits for north-south grid lines are 05, 06, 07, 08, and 09.

(13) The number of the principle digit north-south grid line for the bench marker 221 is 00.

(14) The number of the principle digit east-west grid for bench marker 221 is 91.

(15) (a) Determine the grid square in which each of the following is located:

1 Indian mound, ET 8804.
2 Pond, ES 9690.
3 Road junction, ES 9291.
4 Ford, ES 8981.
5 Cemetery, ES 9684.

(b) Determine the identity of each of the following:

6 The name of the cemetery is Long Cemetery.
7 The name of the church is Red Hill Church.
8 The name of the lake is Sunset Lake.

9 The name of the cemetery is Lincoln Memorial Cemetery.

10 The elevation of the bench marker is 240 feet.

(c) Determine the six-digit coordinate to each of the following:

11 Indian mound, item 2; ET 895044.

12 Pond, item 16; ES 968905.

13 Road junction, item 15; ES 929914.

14 Ford, item 23; ES 895819.

15 Cemetery, item 22; ES 968844.

(d) Identify the object at each of the following six-digit grid headings:

16 At ES 962964; mine or quarry.

17 At ES 935901; a dam.

18 At ET 879009; depression, with water in the depression.

19 At ES 945825; crossing of underground pipe lines.

20 ES 952853; disappearing stream.

1-4. LEARNING ACTIVITY--OBJECTIVE 4

Upon completion of this learning activity, you will be able to explain the use of the numerical (bar) scale on a topographic map to measure ground distance (GD) and road distance on a map.

a. Study Resources--Objective 4.

(1) A map is a graphic representation of a portion of the earth's surface, uniformly and in proportion. This relationship is known as the map scale. The scale on a map permits the determination of distance on a map. The determination of distance on a topographic map is an important factor in the planning and execution of military operations.

(a) Numerical scale. To the map user, the numerical scale is one of the most important features of the topographic map. The numerical scale of a map expresses the horizontal map distance to the corresponding ground distance (horizontal). It is usually written as a fraction and is called a representative fraction (RF). The representative fraction is always written with the map distance as 1. In this fraction, 1 is independent of any specific unit of measure. For example, the RF 1:50,000 means one unit of any measurement on the ground is equal to 50,000 of the same unit on a map; i.e., one foot on the Vine Grove map is equal to 50,000 feet on the ground (fig 1-8).

(b) Measuring ground distance. The ground distance between two points is determined by measuring between them on the map and multiplying map measurement by the RF denominator (fig 1-40).

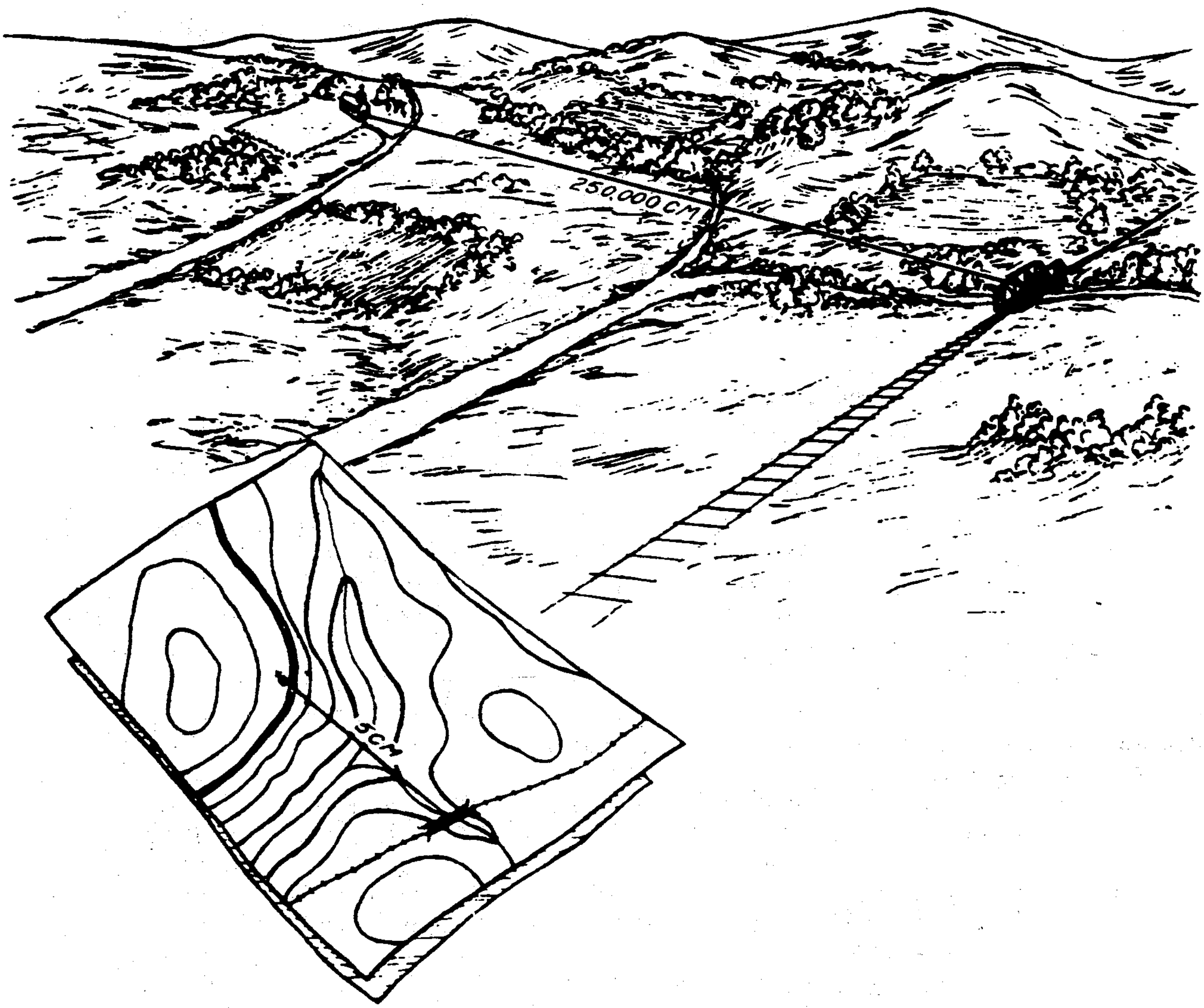


Figure 1-40. Comparing map distance to ground distance.

Example:
RF = 1:50,000

Map distance = 5 units.

5 x 50,000 = 250,000 units of ground distance.

If the above unit of measurement was meters, the problem would be solved using meters; as in figure 1-40, the unit of measurement is centimeters on the map and on the ground.

(c) Sometimes a map or sketch has no representative fraction (RF). To determine ground distance on such a map or terrain sketch, the RF must be determined.

1 One way to compute the RF is comparison with ground distance.

a Measure the distance between two points on the map (MD).

b Determine the horizontal distance between the two points on the ground (GD).

c Utilizing the RF formula:

$$1/X,\ RF = 1/X = \frac{MD}{GD}$$

2 Example:
Refer to figure 1-41.
The distance on the terrain sketch from the bridge (north) to the tank assembly area is 1 inch (MD = 1).

a You walked to the tank assembly area from the bridge and determined the distance to be 1,200 ft, GD (change 1,200 ft to inches by multiplying 12X1200 = 14,400).

b Solve:

$$\frac{1}{X}\ RF = \frac{1}{X} = \frac{MD}{} = \frac{1}{X} = \frac{1}{14,000} = \frac{1}{14,400}$$

c Answer: $\frac{1}{14,400}$

d Both the MD and the GD must be in the same unit of measure; the MD must be reduced to 1.

3 Another way to figure the RF is comparison with another map of the same area that has an RF.

a Select two points on the map with unknown RF. Measure the map distance between the two points.

b Locate the same two points on the map that has the known RF. Measure the distance (MD) between them, using the RF for this map. Determine GD, which is the same for both maps.

c Using the GD and the MD from the first map, determine the RF using the formula:

$$RF = \frac{1}{X} = \frac{MD}{GD}$$

4 Sometimes, it may become necessary to determine MD from a known ground distance and RF. Then, the formula is:

$$MD = \frac{GD}{\text{Denominator of the RF}}$$

Ground distance of the RF

RF = 1:50,000

$$MD = \frac{2{,}200 \text{ meters}}{50{,}000}$$

MD = 0.044 meter (change to centemeter by multiplying by 100)

MD = 4.4 centemeters.

5 When determining ground distance from a map, the scale of the map affects the accuracy of measurement. As the scale becomes smaller, the accuracy of measurement decreases. This is because some of the map features must be exaggerated so that they may be readily defined.

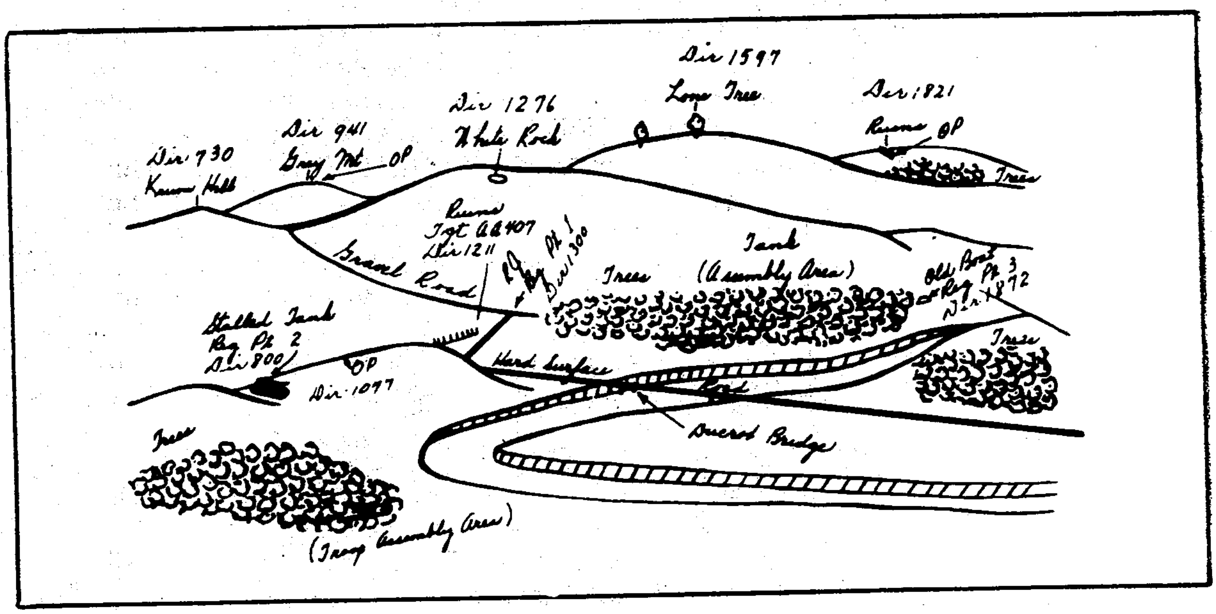


Figure 1-41. Terrain sketch.

(2) On most topographic maps there is another way to determine ground distance: the graphic bar scale.

(a) A graphic scale is a ruler printed on the map on which map distances may be measured as actual ground distance (fig 1-42). To the right of the zero the scale is marked in full units of measure and is called the primary scale. The part to the left of zero is divided into tenths of a unit and is called the extension scale. Most maps have one or more graphic scales, each of which measures distances in a different unit of measure.

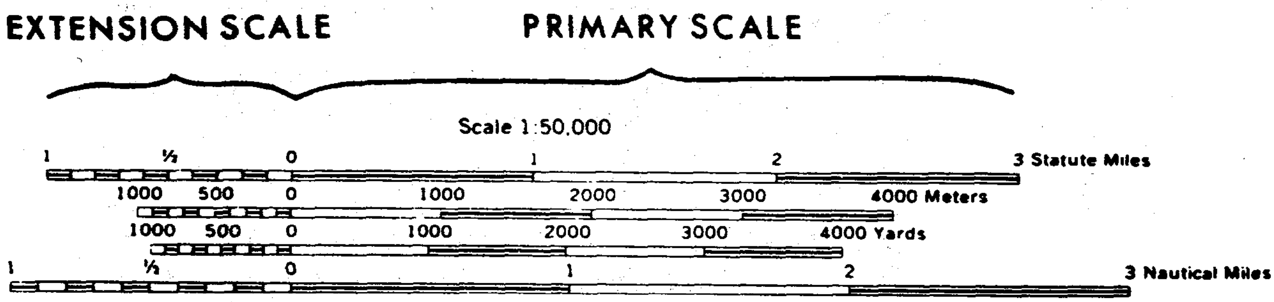


Figure 1-42. Graphic (bar) scale.

(b) To determine straight-line ground distance between two points on a map, lay a straightedge on the map so that the edge of the paper touches both points. Make a tick mark on the edge of the paper at the center of each point. Move the paper down to the graphic scale and read the ground distance between the points. <u>Be sure to use the scale that measures in the unit of measure desired</u> (fig 1-43).

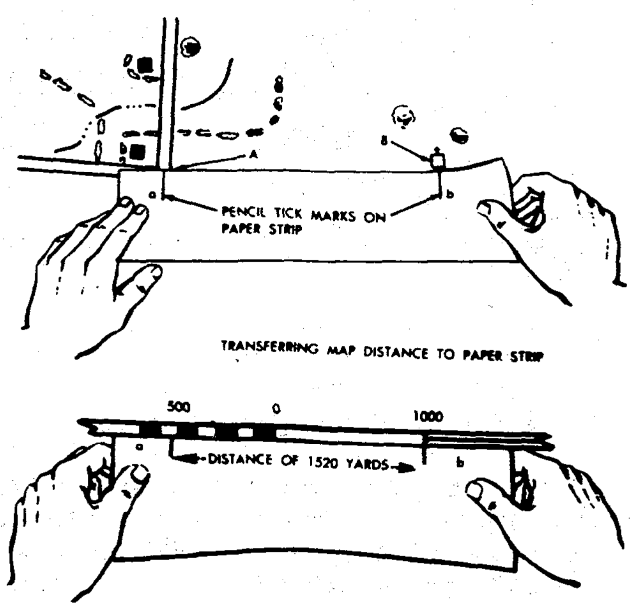


Figure 1-43. Measuring straight-line distances.

(c) To measure along a winding road, stream, or any other curved line, the straight edge of a piece of paper is used again. Make a tick mark at or near the end of the paper and place it at the point from which the curved line is to be measured. Align the the edge of the paper on a straight portion. Make a tick mark on both map and paper at the end of the aligned portion. Keep both tick marks together. Place the point of a pencil on the paper tick mark to hold it in place. Pivot the paper until another approximately straight portion is aligned and again make a tick mark on both map and paper. Continue in this manner until the measurement is complete. Then, place the paper on the appropriate graphic scale and read the ground distance (fig 1-44).

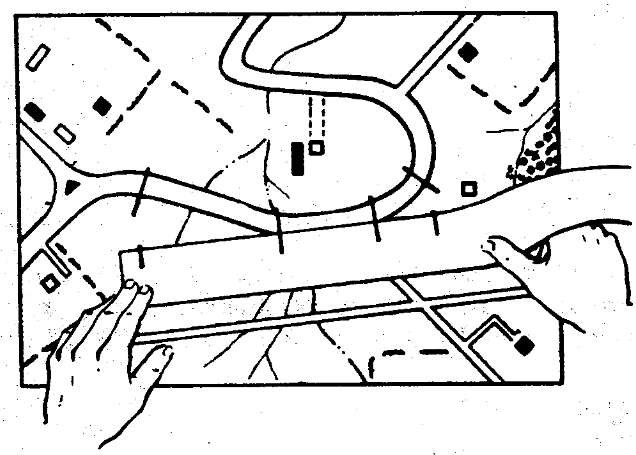


Figure 1-44. Measuring curved line distance on a map.

1 Often, the margin notes give the road distance from the edge of the map to a town, highway, or junction off the map. If the road distance is desired from a point on the map to such a point off the map, measure the distance to the edge of the map and add the distance specified in the marginal note.

- Requirement: Determine the road (Hwy 434) distance from the edge of the map in grid FS 0985 to Lebanon Junction.

- Solve: No measurement requirement.

- Answer: Observe Lebanon Junction, 4 km.

2 It may be desired to measure road distance in kilometers rather than in miles. Large-scale maps do not have kilometer graphics (bar scales). However, the meter graphic can be simply converted to kilometers by moving the decimal point in each figure three places to the left. Remember: 1,000 meters is one kilometer.

(3) The amount of time required to travel a certain distance on the ground is an important factor in most military operations. This can be determined by using the formula:

$$T = \frac{D}{R}$$

R = Rate
D = Distance
T = Time

For example, if an armor unit is road marching at an average rate of 25 kilometers per hour, it will take approximately 3 hours to travel 75 kilometers.

$$\frac{75(D)}{25(R)} = 3(T)$$

b. Practice Exercise--Objective 4.

(1) Refer to the Vine Grove map sheet. Using grid squares as measuring devices, estimate the ground distance in meters from the saddle in grid square ES 9698 (vicinity ES 960983) to the large hilltop in the lower left section of grid square ES 9798.

(a) 1,500 meters.
(b) 1,900 meters.
(c) 1,400 meters.
(d) 1,100 meters.

(2) Determine the ground distance (GD) from the radio tower (vicinity ES 927904) (WSAC) to the unimproved surface road in grid square ES 9990 to the point where the NS grid 99 apparently touches the unimproved surface. Measure the distance on the map and obtain a map distance (MD) of 5 inches.

(a) 63,000 meters.
(b) 6,350 meters.
(c) 63,500 meters.
(d) 6,000 meters.

(3) For the purpose of this problem, you find a portion of a Vine Grove map without a representative fraction (RF). You measure the map distance (MD) from Maffet Cemetery in grid square ES 9981 to the hilltop, with an improved all-weather, hard-surface road near the top of the hill, in grid square 9983, and determine the distance to be 2 inches. You also determine the ground distance (GD) to be 200 yards. What is the scale of the map?

(a) 1:3,600.
(b) 1:36,000.
(c) 1:6,300.
(d) 1:3,900.

(4) What is the scale of a map if the map distance, MD, is 3 inches and the ground distance, GD, is 6,000 feet?

(a) 1:12,000.
(b) 1:2,000.
(c) 1:12,500.
(d) 1:24,000.

(5) When given two different maps of the same area, one of known scale and the other of unknown scale, it will be necessary to compute the scale of the unknown map. If you measured 4 inches on a map with an RF scale of 1:48,000, what is the actual ground distance (GD)?

(a) 48,000.
(b) 144,000.
(c) 192,000.
(d) 96,000.

(6) Refer to question (5), above; in addition to the map mentioned, you have another map, scale (RF) unknown. The map distance between the same two points on the map will determine the map scale. What is the scale, if the map distance is determined to be 2 inches?

(a) RF = 1:32,000.
(b) RF = 1:50,000.
(c) RF = 1:24,000.
(d) RF = 1:96,000.

(7) You have a map with a RF of 1:250,000 and a measured map distance (MD) of 5 inches between two points. You have another map which does not have an RF scale, but the map distance on the unknown scale is equal to 2 inches between the same two points. What is the RF scale of the map without a scale?

(a) 1:25,000.
(b) 1:125,000.
(c) 1:250,000.
(d) 1:625,000.

Note. Another way to measure ground distance on the map is to use the bar scale (fig 1-45). The bar scale is the ruler, graduated in miles, meters, and yards, which appears in the bottom margin. You will normally use the bar scale by "taking the measured map distance to the scale." One good way is to tick mark the distance to be measured on the edge of a sheet of paper. The measurement is placed so that the right-end tick falls on an even reading and the left-end tick falls in the subdivided section to the left of zero (0).

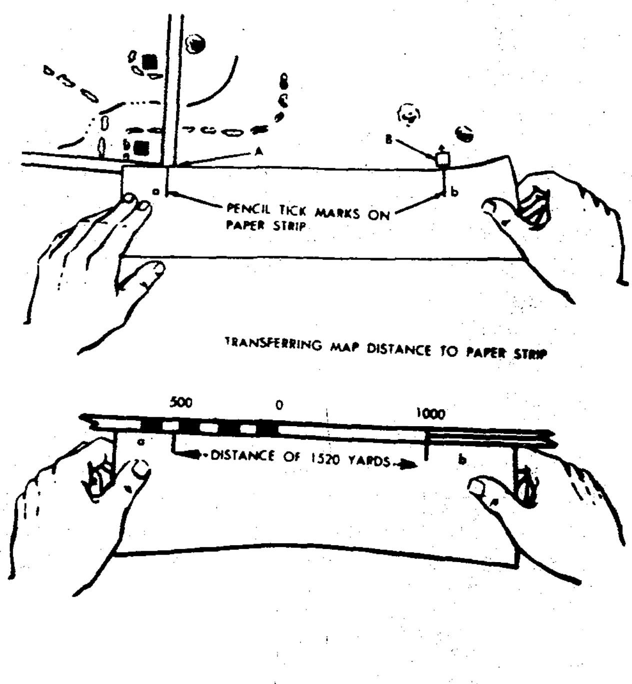


Figure 1-45. Measuring tick marks on the bar scale.

(8) Refer to figure 1-45. The map distance shown is equal to how many yards of ground distance?
   (a) 1,400.
   (b) 1,505.
   (c) 1,520.
   (d) 1,580.

(9) Refer to the Vine Grove map, Special Map 10 and figure 1-46. Using the tick mark bar scale method, what is the ground distance in meters from Daugherty Cemetery in grid square FS 0590 to the southwest end of the airstrip (soft) in grid square FS 0893?
   (a) 4,800 meters.
   (b) 48,000 meters.
   (c) 4,300 meters.
   (d) 44,000 meters.

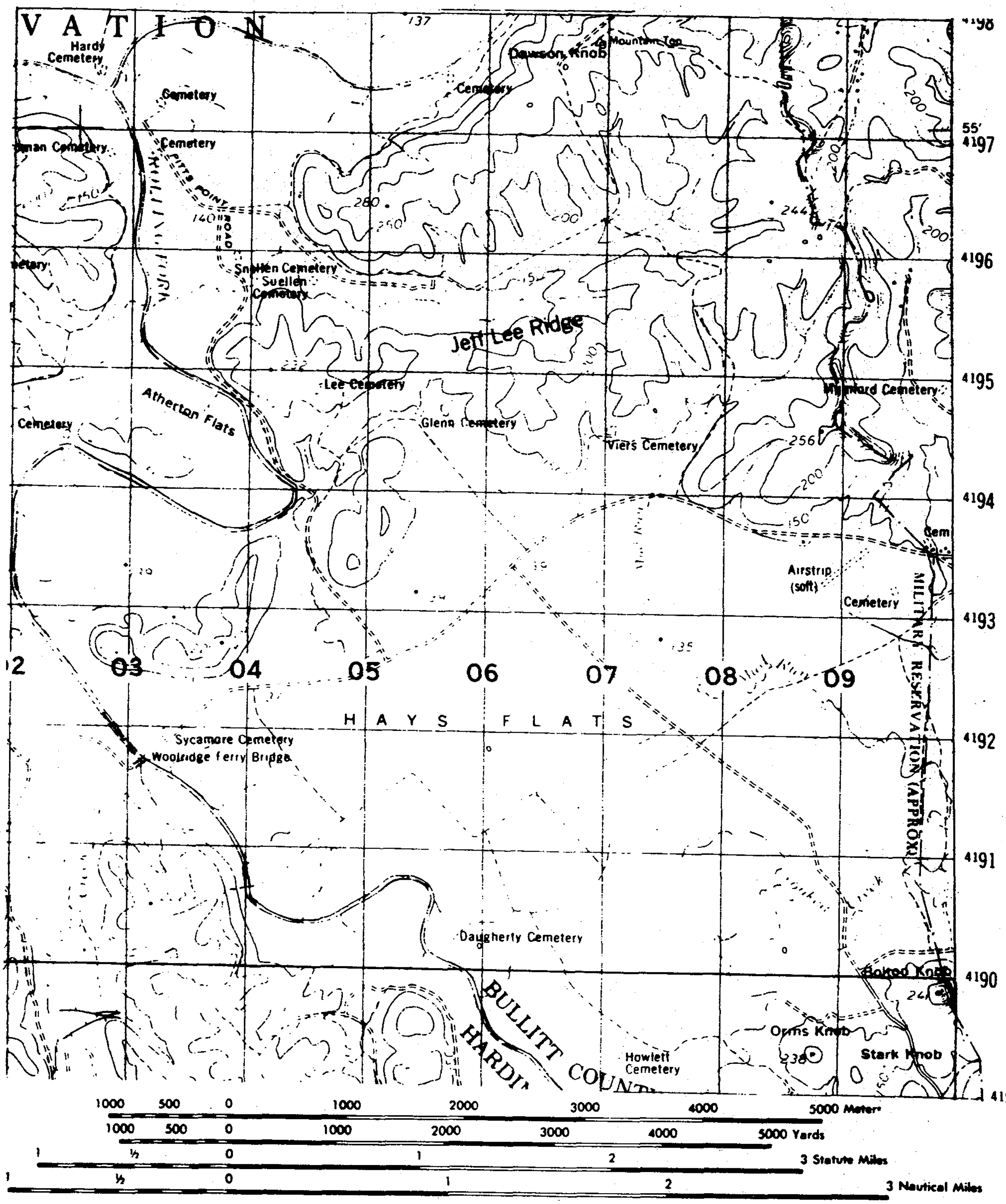


Figure 1-46. Map and bar scale.

(10) Refer to special map 10 and figure 1-46. Determine the nautical miles from Woolridge Ferry Bridge in grid square FS 0391 to the southwest end of the airstrip (soft) in grid square FS 0892.

(a) 1 2/10 nautical miles.
(b) 3 2/10 nautical miles.
(c) 4 9/10 nautical miles.
(d) 3 9/10 nautical miles.

(11) Determine the road distance in statute miles from the end of the map at Stark Knob in grid square FS 0989 (light duty, all-weather, hard or improved surface) to Woolridge Ferry Bridge in grid square FS 0391.

(a) 10.9 statute miles.
(b) 8.9 statute miles.
(c) 9.8 statute miles.
(d) 11.9 statute miles.

(12) Determine the distance in meters from the hilltop in FS 0493 to Bolton Knob (hilltop) in grid square FS 0989.

(a) 6,700 meters.
(b) 6,100 meters.
(c) 7,100 meters.
(d) 7,400 meters.

c. <u>Solution to Practice Exercise--Objective 4.</u>

(1) (d) 1,100 meters.
(2) (b) 6,350 meters.
(3) (b) 1:36,000.
(4) (d) 1:2400.
(5) (d) 192,000.
(6) (c) 1:96,000.
(7) (c) 1:625,000.
(8) (c) 1,520 meters.
(9) (c) 4,400 meters. (+ -) 100M
(10) (b) 3 2/10 nautical miles.
(11) (b) 8.9 statute miles.
(12) (b) 6,100 meters.

LESSON TWO

OBJECTIVE: Task No. To be determined.

TASK: Upon completion of this lesson, you will have a basic knowledge of how to measure angles for direction on a topographic map, use the lensatic compass, and orient a map using a compass and field expedient methods.

CONDITIONS: You will have Subcourse Booklet AR0120 and an examination response sheet. You will work at your own pace and in your own selected environment with no supervision.

STANDARDS: Within approximately three hours you should be able to study the lesson, answer the practice exercise questions, and select the correct response for each examination question. You must respond correctly to 75 percent of the examination in order to receive credit for the subcourse.

CREDIT HOURS: 3.

REFERENCES: FM 21-26, "Map Reading" and FM 21-31, "Topographic Symbols."

2-1. LEARNING ACTIVITY—OBJECTIVE 5

Upon completion of this learning activity, you will be able to explain how to measure angles and compute direction (azimuth) on a topographic map.

a. Study Resources—Objective 5.

(1) Directions are expressed in everyday life as right, left, straight ahead, etc.; but the question arises, "to the right of what?" Military personnel require a method of expressing a direction that is accurate, is adaptable for use in any area of the world, and has a common unit of measurement. The four principle points of the compass and the map are north, south, east, and west. The top of the map is north, the right margin is east, the left margin is west, and the bottom of the map is south (fig 2-1).

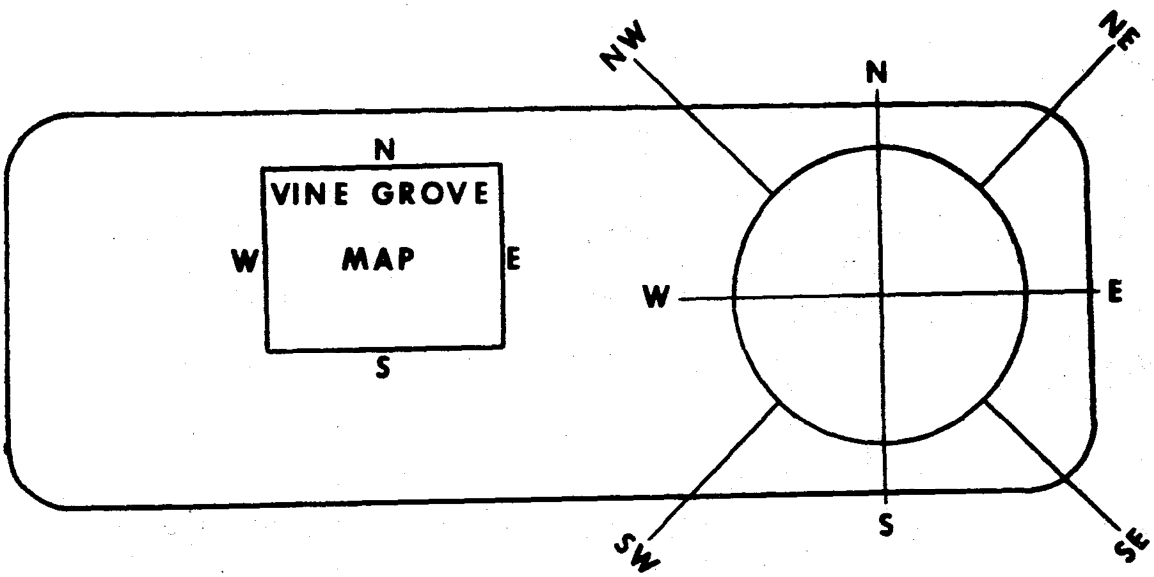


Figure 2-1. Directions and halfway points.

(a) Directions are expressed as a unit of angular measure. There are several systems used.

1 The most commonly used unit of angular measure is the degree, with its subdivision of minutes and seconds.

2 Another unit used is the mil; the symbol is m̸. For US military purposes, a complete circle is divided into 6,400 mils. The mil is commonly used in artillery, tank, infantry, and mortar gunnery. It is convenient for many practical uses because it subtends approximately one unit of length at a distance of 1,000 units, making it adaptable for many military purposes.

(b) The grad is a unit of measure found on some foreign maps. There are 400 grads in a complete circle. (A 90° right angle equals 100 grads.) The grad is divided into 100 centesimal minutes and the minutes into 100 centesimal seconds (miligrads). This unit of measure is relatively easy to use with the metric sytem.

(2) Base lines and directions.

(a) To measure anything there must always be a starting point, or zero measure, and a point of reference. These two points designate the base one reference line. There are three base lines: true north, magnetic north, and grid north. For military purposes, the most commonly used are magnetic and grid north: magnetic when working with a compass and grid when working with a map. There will be situations when necessary to convert a grid direction or azimuth to a magnetic azimuth. This process will be discussed later in this subcourse.

1 True north. A line from any position on the earth's surface to the north pole. All lines of longitude are true north lines. True north is usually symbolized by a star (fig 2-2). True north is rarely used for military purposes.

2 Magnetic north. The direction to the north magnetic pole, as indicated by the north-seeking needle of a magnetic instrument. Magnetic north is usually symbolized by a half arrowhead (figure 2-2).

3 Grid north. The north established by vertical grid lines on a map. Grid north may be symbolized by the letters GN or the letter y (figure 2-2).

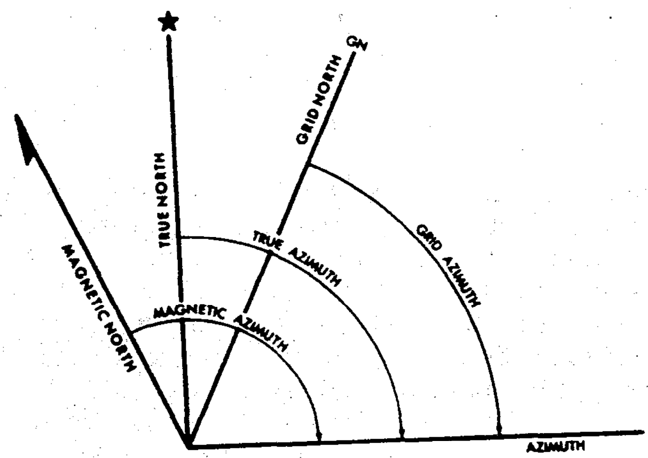


Figure 2-2. True, grid, and magnetic azimuths.

(b) Azimuth and back azimuth. The most common military method of expressing a direction is by using azimuths. An azimuth is defined as a horizontal angle measured clockwise from a north base line (magnetic, grid, or true). When the azimuth between two points on a map is desired, the points are joined by a straight line; a coordinate scale protractor measures the angle between grid north and the drawn line. This measurement is the grid azimuth of the drawn line (figure 2-3).

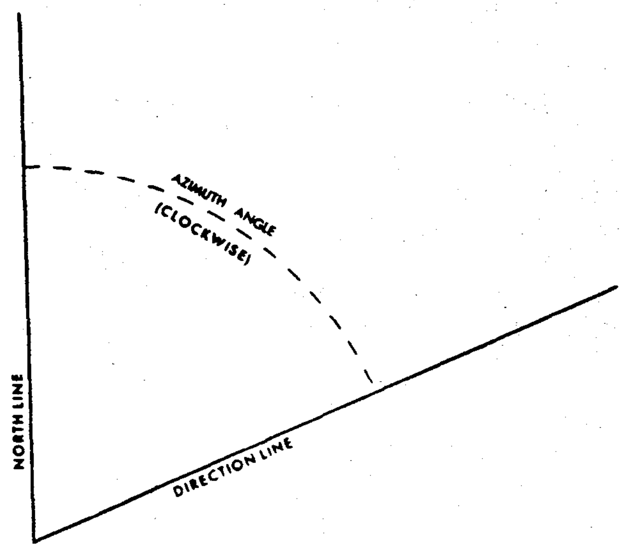


Figure 2-3. Azimuth angle.

1 When using an azimuth, the point from which the azimuth originates is imagined to be the center of the azimuth circle (fig 2-4). Azimuths take their name from the baseline from which they have been measured: true azimuth from true north, magnetic north from magnetic north, and grid azimuth from grid north (fig 2-2). Therefore, any one direction can be expressed in three ways: a grid azimuth, if you measure on a military map; a magnetic azimuth, if you measure by a compass; and a true azimuth, if you measure from a meridian or longitude.

2 A back azimuth is the reverse direction of an azimuth. It is comparable to doing an "about face," in which the person or object is turned completely opposite to the previous direction. To obtain a back azimuth from an azimuth, subtract 180° if the azimuth is 180° or more; add 180° if the azimuth is 180° or less (fig 2-5).

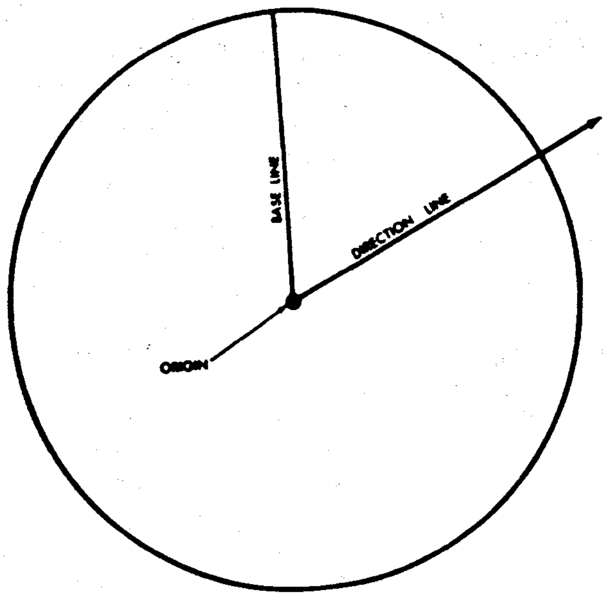


Figure 2-4. Azimuth Circle.

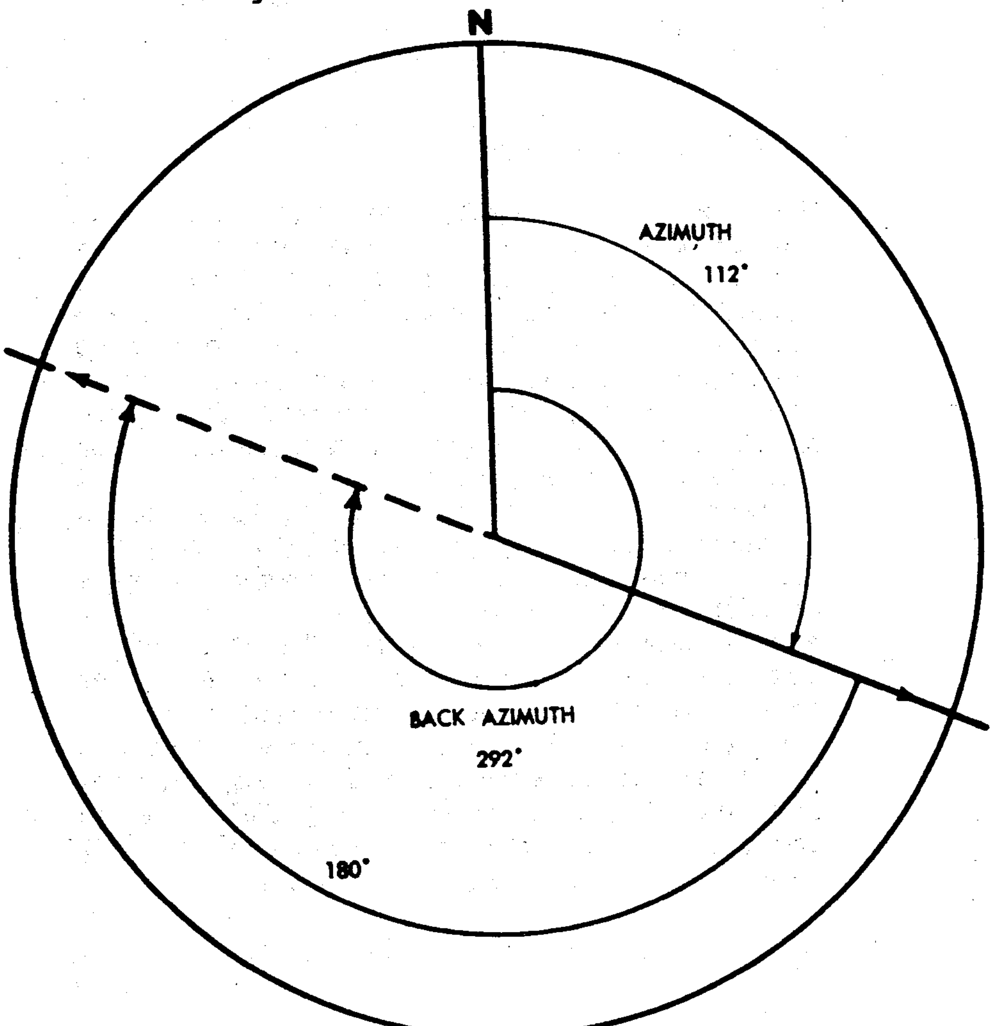


Figure 2-5. Computing azimuths.

(c) Declination diagram.

1 A declination diagram is placed on most large-scale maps to enable the user to orient the map properly. The diagram shows the interrelationship of magnetic north, grid north, and true north (fig. 2-6). On medium-scale maps, declination information is shown by a note in the map margin (fig 2-6).

2 Declination is the angular difference between true north and either magnetic or grid north. There are two declinations: a magnetic declination and a grid declination.

3 The declination diagram contains three prongs representing magnetic north, grid north, and true north (fig 2-6).

a G-M angle. An arc, indicated by a dashed line, connects the grid north and the magnetic north prongs. The value of this arc--the grid magnetic angle (G-M ANGLE) --states the size of the angle between grid north and magnetic north and the year the map was prepared. This value is expressed to the nearest $1/2^{o}$, with mil equivalents shown to the nearest 10 mils.

b Grid convergence. An arc, indicated by a dashed line, connects the prongs for true north and grid north. The value of the angle for the center of the sheet is given to the nearest full minute, with its equivalent to the nearest mil. These data are shown in the form of a grid convergence note.

c Conversion notes. Notes may also appear with the diagram explaining the use of the G-M angle. One note provides instructions for converting magnetic azimuth to grid azimuth and the other note for converting grid azimuth to magnetic azimuth. The conversion (add or subtract) is governed by the direction of the magnetic north prong relative to that of the grid north prong.

4 The grid north prong is always aligned with the easting, or vertical grid lines on the map. On most maps, the grid north prong is formed by an extension of an easting grid line into the margin. The angles between the prongs, however, are seldom plotted exactly. The relative position of the directions is

obtained from the diagram, but the numerical value should not be measured from it. For example, if the amount of declination from grid north to magnetic north is 1°, the arc shown in the diagram may be exaggerated; if measured, it may have an actual value of 5°. The position of the three prongs in relation to each other varies according to the declination data for each map. It is often necessary to convert from one type of direction to another. A magnetic compass reading gives a magnetic azimuth, but to plot this line on a gridded map, the magnetic azimuth value must be changed to a grid azimuth. The reverse is true when orientation is taken from the map; the grid azimuth measured from the map must be converted to a magnetic azimuth for use with the magnetic compass. The declination diagram is used for these conversions. Most maps include, with the diagram, the grid-magnetic (G-M) angle and notes explaining its use to convert from one azimuth to another. On older sheets which do not show this information, it is necessary to determine whether to add or subtract the difference to the given azimuth to obtain the desired one. A rule to remember when solving such problems is this: no matter where the azimuth line points, the angle to it is always measured clockwise in the northern hemisphere from the reference direction (base line). With this in mind, the problem is solved in three easy steps.

<u>a</u> Examine the declination diagram on the map (fig 2-6).

<u>b</u> From the base of the declination diagram,

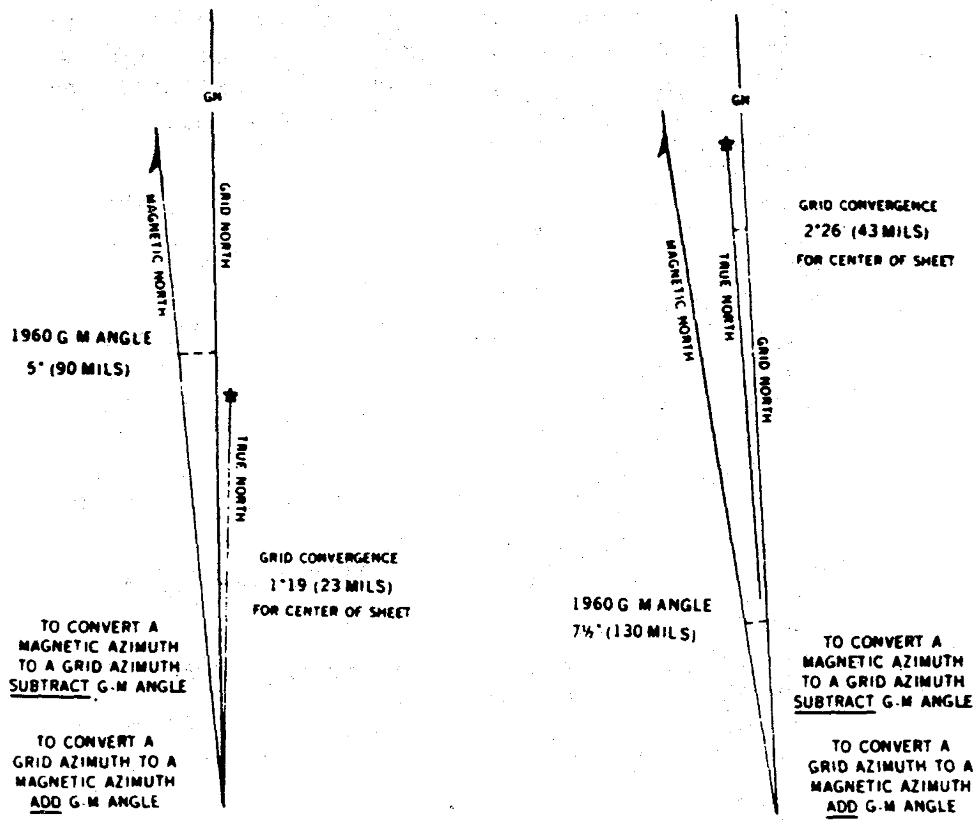


Figure 2-6. Declination diagrams.

draw an arbitrary line at roughly right angles to the general direction of north, regardless of the actual value of the azimuth in degrees (fig 2-7). The position of the arbitrary line in relationship to the declination diagram is of little importance. Figure 2-8 shows an arbitrary line drawn at a different angle. It is both simple and correct to use such an arbitrary line to represent the azimuth line. Remember that the line itself does not change position, but its angular value is changed because of measurement from different reference directions.

c Complete the diagram by drawing an arc from each reference line to the arbitrary azimuth line. A glance at the completed diagram shows whether the given azimuth is greater, and thus whether the known difference between the two must be added or subtracted (fig 2-9).

d After the correct conversion rules have been determined, they should be noted in the map margin, adjacent to the declination diagram, for future reference.

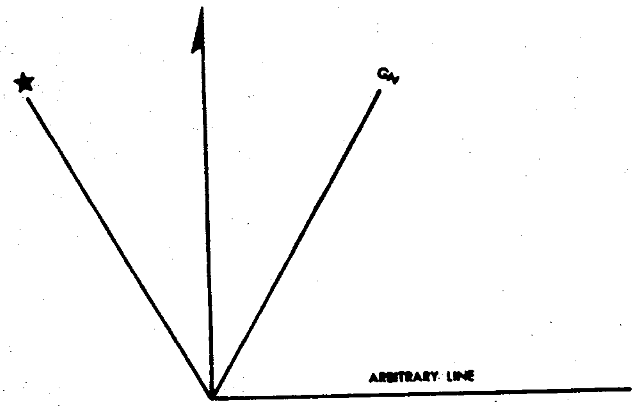


Figure 2-7. Declination of diagram with arbitrary line.

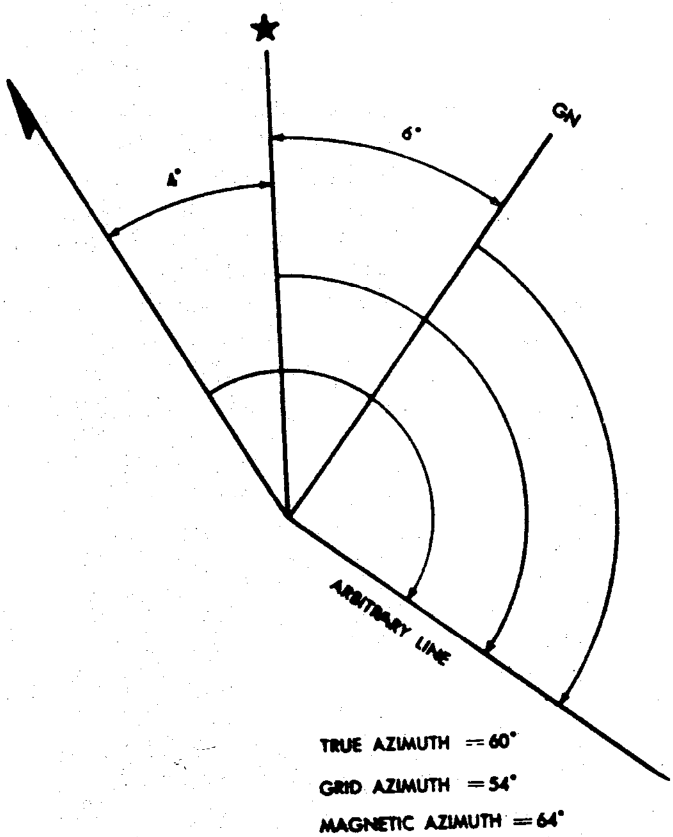


Figure 2-8. Azimuth angle relationship.

e Some older maps have a note under the declination diagram for a certain year and the amount of annual change. The annual change is so small, when compared to the $1/2^{o}$ value of the G-M angle, that it is not shown on the standard large-scale maps. Annual change may be disregarded in some situations.

5 How to measure azimuth on a map.

Note. Refer to figure 2-9 and the Vine Grove map sheet. Answer the following questions: What is the grid azimuth (direction) to Viers Cemetery in grid square ES 0794 from the hilltop in grid ES 0493?

Step 1. Locate the center of mass of the hilltop and Viers Cemetery.

Step 2. Place a small pencil point on the center of mass of the hilltop and the cemetery. Using the coordinate scale protractor as a straightedge, draw a line through the center of mass of both objects. Make the line a quarter of an inch longer than the length of the coordinate scale protractor.

Step 3. Place the center index line (+) of the coordinate scale protractor exactly on the center object you wish to measure from. (Be sure to hold the coordinate scale correctly.) Insure that the north-south grid line on the map and the vertical line (0 at the top) on the coordinate scale protractor are exactly parallel. Do this by counting degree marks left or right to a vertical grid line. Count from 0 to the line, and from 180 to the same line. You should have the same number of degree marks from each. (For this problem you should have 2 $1/2^{o}$ from 0 right to 05 line, and 2 $1/2^{o}$ from 180 right to the 05 line.)

Step 4. Read the degree scale (inner), noticing the number and scale increments between numbers over the direction line previously drawn. The azimuth to Viers Cemetery is the number read 63°. You should get this reading, plus or minus 3°.

Problem: Using the above method, determine the direction (azimuth) of Woolridge Ferry Bridge in grid square ES 0391 from the airstrip (soft) in grid square ES 0893 and 0993.

Answer: Grid azimuth is 254°.

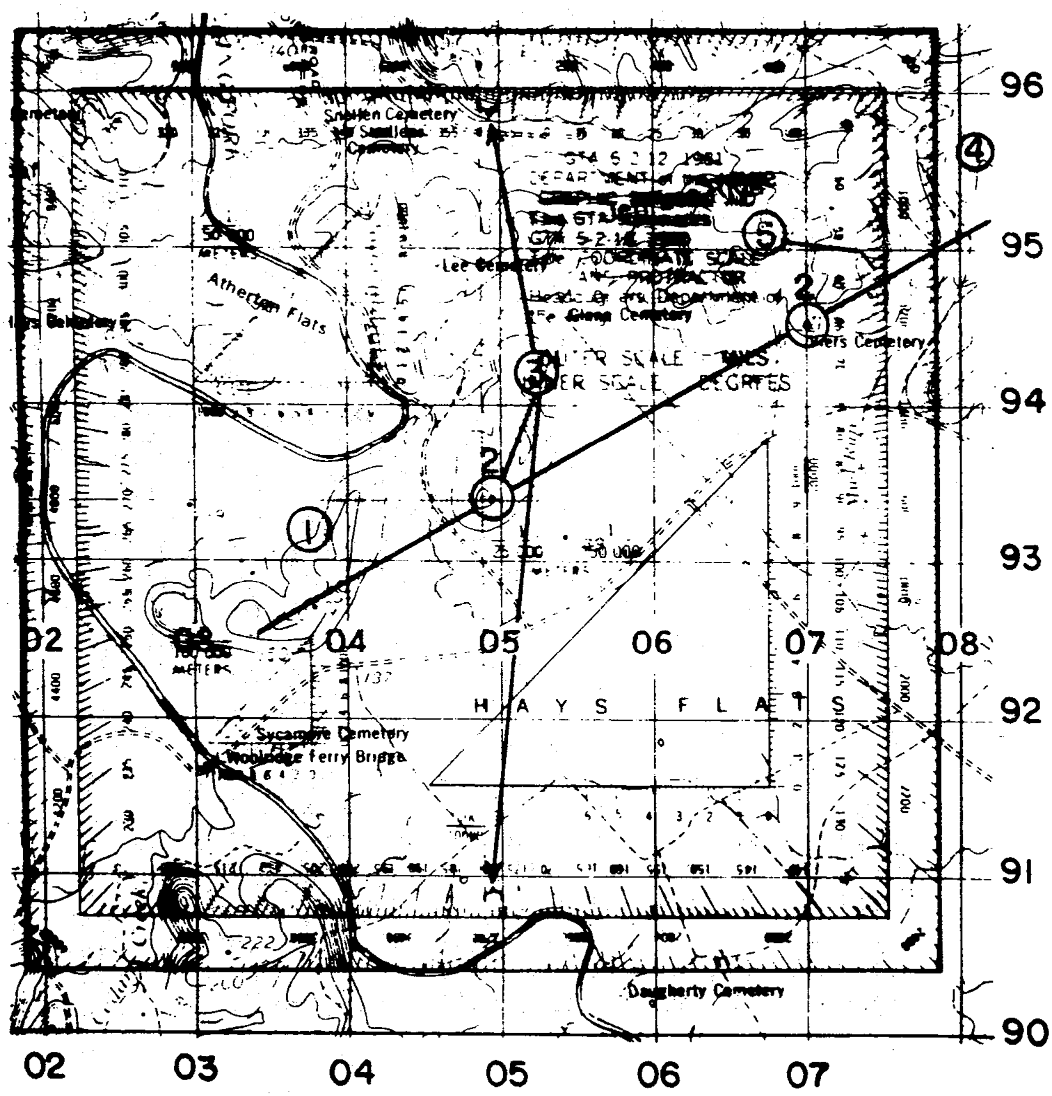


Figure 2-9. Measuring azimuths.

(3) <u>The compass and how to use it</u>.

(a) The lensatic, or magnetic, compass is the most commonly used and simplest instrument for measuring directions and angles in the field. There are two varieties of compasses used in the United States Army as standard equipment: the lensatic compass and artillery (M2) compass. The artillery compass is a special purpose instrument and will not be discussed in this subcourse. Information on the M2 compass is found in TM 9-1290-333-15. There are two general rules to follow when using the lensatic compass.

1 Keep the compass away from metal objects or high-tension wires. The north arrow of the compass is controlled by lines of force in the earth's magnetic field. These forces are disturbed locally by amounts of iron and electric fields that will produce error in a compass reading. Even metal-rimmed glass will affect the compass reading. The effect will be greater as the mass of the object or strength of the field increases. The extent of the effect can be determined by holding the compass in the palm of the hand and slowly walking away from the object until the dial remains still.

2 Keep the compass closed when not in use. The compass is a delicate instrument and may be damaged easily. It should be properly closed and returned to its carrying case after use.

(b) Nomenclature. The lensatic compass consists of a case in which a magnetized dial or card is mounted on a pivot so it can rotate freely when the compass is held level. Printed on the dial in luminous (light-emitting) figures are an arrow and the letters E and W. The arrow always points to magnetic north and the letters fall at east (E) 90° and west (W) 270° on the dial. There are two scales. The outer scale is in mils and the inner scale is in degrees. We will be concerned with the degree scale. The front sight is a sighting set into a slot in the cover. The rear sight has a slot for sighting on the object and a lense for reading the dial (fig 2-10). The rear sight also serves as a lock, and clamps the dial when closed. It must be opened to more than 45° from the bezel (glass face) so the dial will float freely.

NOTE. The straightedge on the left side of the compass, when opened, has a coordinate scale. Most newer compasses have a 1:50,000 scale.

CAUTION: Some older compasses will have a 1:25,000 scale. You can use this with a 1:50,000 scale map, but the values you read must be halved. CHECK YOUR SCALE.

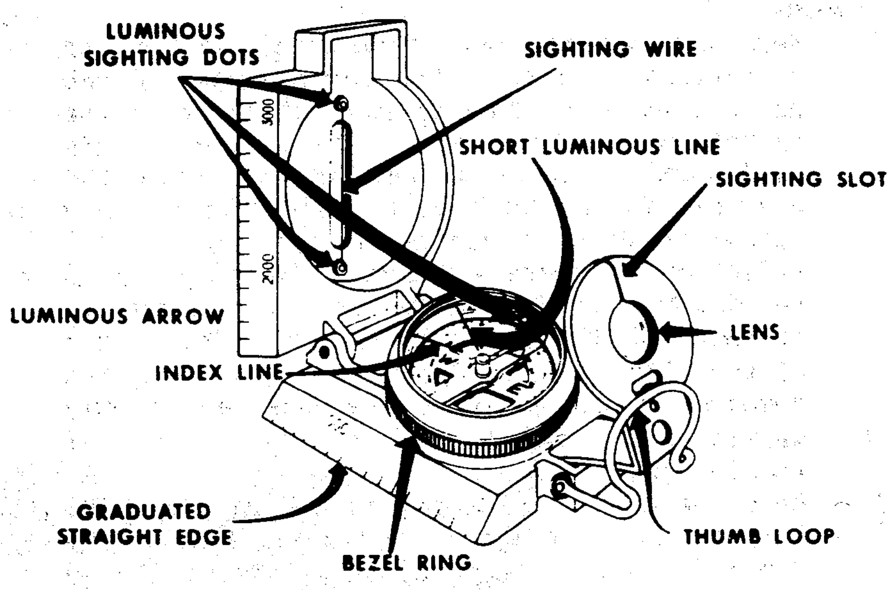


Figure 2-10. Lensatic compass.

(c) Use of the compass. One method of using the compass is called the center-hold technique. First, open the compass so that the cover forms a straightedge with the base. The lens of the compass is moved out of the way. Next, place your thumb through the thumb loop, form a steady base with your third and fourth fingers, and extend your index finger along the side of the compass. Place the thumb of the other hand between the eyepiece and the lens; extend the index finger along the remaining side of the compass and the remaining fingers around the fingers of the other hand. Pull your elbows firmly into your sides. This will place the compass between your chin and your belt. To measure an azimuth, simply turn your entire body toward the object, pointing the compass cover directly at the object. Once you are pointing at the object, look down and read the azimuth from beneath the fixed black index line. Research has indicated that the center-hold technique is just as accurate as the more familiar sighting method. More important, the center-hold technique offers the following advantages over the sighting technique:

<u>1</u> It is faster to use.

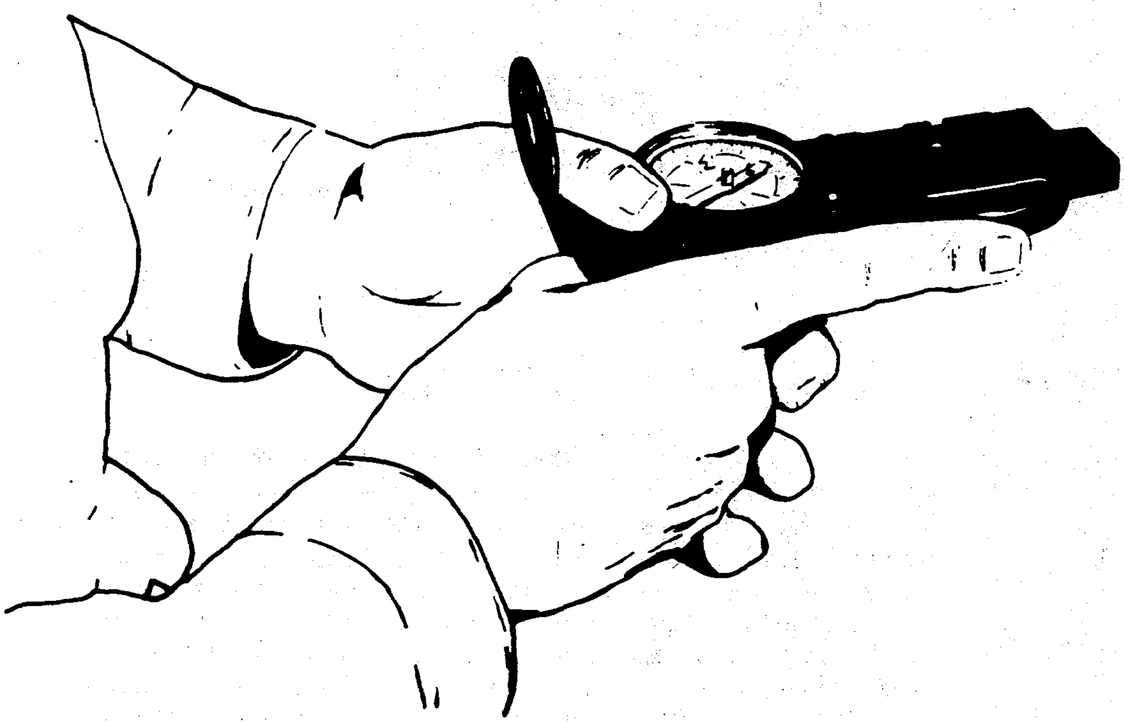
<u>2</u> It is easier to use; the number of steps required for efficient operation has been reduced from seven to two.

<u>3</u> It can be used under <u>all</u> conditions of visibility.

<u>4</u> It can be used when navigating over all types of terrain.

<u>5</u> It can be used without putting down the rifle; however, the rifle must be slung well back over either shoulder.

<u>6</u> It can be used without removing the steel helmet or eyeglasses.



NOTE: The sighting method is not taught in subcourse.

Figure 2-11. Center-hold technique.

(d) Presetting an azimuth at night. Different models of the lensatic compass vary somewhat in the details of their use at night, but the principles are the same. Mounted over the dial in addition to the stationary glass cover or fixed crystal is a movable crystal set in a bezel ring; on this movable crystal is at least one luminous line.

1 When a light source is available, hold the compass in the palm of the hand and rotate it until the desired azimuth falls under the index line; turn the bezel ring until the luminous line comes over the north arrow. Make sure that, when the north arrow is under the luminous line, your azimuth is under the index line.

2 When a light source is not available, an azimuth may be set on the compass by the click method. As the bezel ring is rotated, a series of clicks is heard. Each of these clicks represents 3°. If the desired azimuth is divided by 3, the number of clicks which must be set off can be determined. To set the azimuth on the compass, rotate the bezel ring until the long luminous line is directly over the index line. Then, holding the compass in one hand, rotate the bezel ring the desired number of clicks.

3 With the compass preset as described above, rotate the compass until the north arrow falls directly under the luminous line. The body of the compass and the sighting wire are pointing along the desired azimuth. Look over the sighting slot and find an object along the desired azimuth. If in a party, it may be expedient to send a man ahead as far as he can be seen and direct him right or left until he is on the desired azimuth. Then, move up to his position, reorient the compass with the north arrow under the luminous line, and repeat the process.

4 The presetting procedure outlined above may also be utilized for daylight compass use.

(e) Deliberate offset. An offset is a planned magnetic deviation to the right or left of an azimuth to an objective. It is used when approaching a linear feature from the side and a point along the linear feature (such as a road junction) is the objective. Because of errors in the compass or in map reading, one may reach the linear feature and not know whether the objective lies to the right or left. A deliberate offset by a known number of degrees in a known direction compensates for possible errors. Ten degrees is an adequate offset for most tactical uses. A deliberate offset also insures that upon reaching the linear features, the user knows whether to go right or left to reach the objective.

(f) Detouring an obstacle.

1 To bypass enemy positions or obstacles and still stay oriented, detour the obstacle by moving at right angles for specified distances. For example, you are moving on an azimuth of 90° and wish to bypass an obstacle or position. Change your azimuth to 180° and travel for 100 meters, change your azimuth to 90° and travel for 150 meters, change your azimuth to 360° and travel for 100 meters, then change your azimuth to 90° and you are back on your original azimuth line.

2 Bypassing an unexpected obstacle at night is a fairly simple matter. To make a 90° turn to the right, hold the compass in the center-hold technique; turn until the center of the luminous letter E is under the luminous line (do not move the bezel ring). To make a 90° turn to the left, turn until the center of the luminous letter W is under the luminous line. This does not require changing the compass setting (bezel ring), and it insures accurate 90° turns.

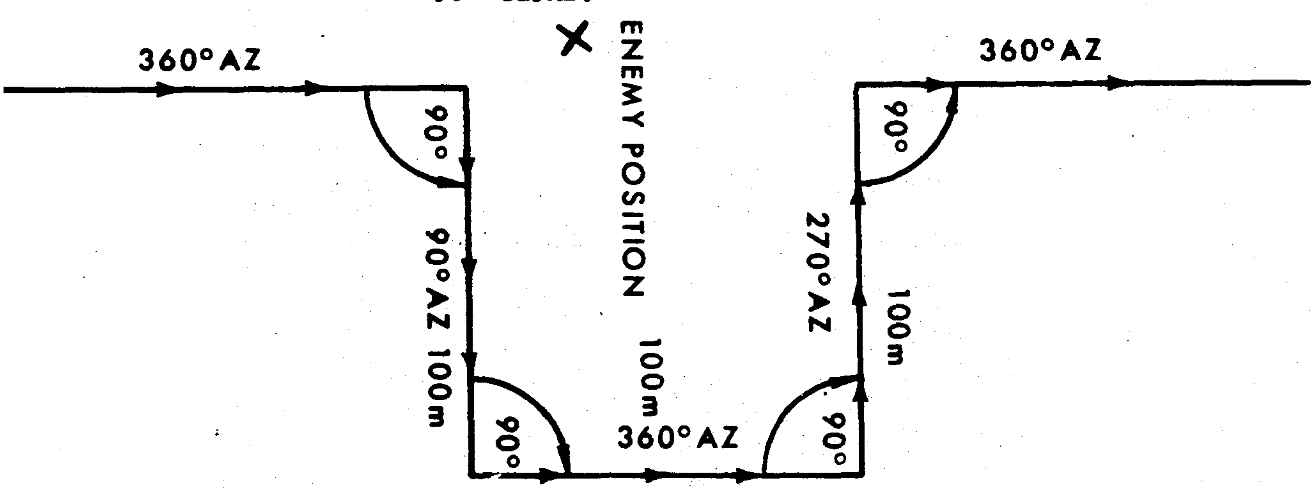


Figure 2-12. Detouring an obstacle.

(g) Determining distance in the field.

1 The navigator must have some means of determining distance traveled while moving over the terrain.

2 Pacing is probably the most common method of measuring distance. A pace is equal to one natural step. Measuring by pacing is simply counting the paces between two points on the ground and converting this to ground distance. Each individual must determine his average pace over varying terrain by pacing a known ground distance six times and computing the mean. Varying conditions of terrain and weather, as well as the individual and his equipment, will affect pace length. Experience in varying types of terrain is of utmost importance in accurate pacing. The following are general guides for the effect of conditions on pacing:

a Slopes. The pace lengthens on down-grade and shortens on up-grade.

b Winds. A headwind shortens the pace and a tailwind increases it.

c Surfaces. Sand, gravel, mud, and similar surface material tend to shorten the pace.

d Elements. Snow, rain, or ice causes the pace to be reduced in length.

e Clothing. Excess clothing shortens the pace.

f Stamina. Fatigue affects the pace.

(h) How to count paces. The average pace is a little less than 1 meter. The average man uses 116 spaces to travel 100 meters. Check your pace length by practicing on a known 100-meter distance--like a football field plus one endzone which is 110 yards, approximately 100 meters.

1 Cross-country pacing. When traveling cross-country the pace will increase considerably. For example, a person taking 116 paces per hundred meters will take approximately 120-125 paces per hundred meters when traveling cross-country. When determining your pace for cross-country or field travel, pace yourself over 600 meters of cross-country terrain to determine how many paces are taken per average 100 meters.

2 Determine how many paces it takes you to walk 100 meters on both level terrain and cross-country.

b. Practice Exercise--Objective 5.

(1) Directions are expressed as units of angular measure. Name the unit most commonly used to measure angles in ground navigation in the United States Army.
   (a) Seconds.
   (b) Mils.
   (c) Degrees.
   (d) Grads.

(2) Baseline or reference line is the
   (a) north from which the azimuth is measured.
   (b) angular difference when measured from true north.
   (c) distance measured from the magnetic field to true north.
   (d) distance measured from grid to magnetic north.

(3) The imaginary baseline from any position on earth to the north pole is known as
   (a) true north.
   (b) magnetic north.
   (c) general north.
   (d) grid north.

(4) The north that is established by vertical grid line on a map is known as
   (a) magnetic north.
   (b) grid north.
   (c) north.
   (d) true north.

(5) An azimuth measures the horizontal angle between two points from a baseline of
   (a) true north, magnetic north, or north.
   (b) magnetic north, general north, or true north.
   (c) north, general north, or far north.
   (d) grid north, magnetic north, or true north.

(6) The point from which the azimuth originates is imagined to be the center of the
   (a) concentric circle.
   (b) azimuth circle.
   (c) aiming circle.
   (d) diamond circle.

(7) When computing azimuth, a back azimuth changes the direction 180 degrees. What is the back azimuth of 144°?
   (a) 243°.
   (b) 342°.
   (c) 324°.
   (d) 234°.

(8) A ___________ is placed on most large scale maps to enable the user to ________ the map _________.
(a) declination, read, properly
(b) declination, support, properly
(c) declination, orient, properly
(d) declination, revise, properly

(9) A G-M angle is an
(a) azimuth.
(b) angular difference between true north and general north.
(c) arc.
(d) azimuth indicator.

(10) Using the declination diagram on the Vine Grove map sheet, solve the following problem: you wish to convert a magnetic azimuth to a grid azimuth; the GM angle should be ________ to/from the magnetic azimuth.

(11) On some large-scale maps, the annual magnetic change of the declination diagram is so _________ its value is not shown on some standard _________ scale maps.

(12) The standard compass used by the soldier in the field to measure ___________ and ________ is the lensatic compass.

(13) When using the compass, one should keep away from _________ objects and _______________ wires.

(14) On the compass, the north-seeking magnetic arrow always points to ___________ north.

(15) A pace is the average step used to measure distance. Each soldier should accurately measure his pace per ____ meters over a course of _____ meters for level terrain and _____ meters for cross-country.

(16) When ground features and map symbols are aligned to correspond with each other and the user position is fixed on the ground and on the map, the map is
(a) detail-situated.
(b) organized.
(c) oriented.
(d) compromised.

(17) When the map and compass are aligned, either the straightedge of the compass, or the black index line is placed parrallel to any vertical grid line on the map and the magnetic needle points to magnetic north, the face of the compass will match the _________ _________ of the map.

(a) inclination diagram
(b) declination diagram
(c) situation diagram
(d) orientation diagram

c. Solutions to Practice Exercise—Objective 5.

(1) (b) mils.

(2) Baseline or reference line is the "north" from which the azimuth is measured; i.e., true north, grid north, and magnetic north.

(3) (a) true.

(4) (b) grid north.

(5) (d) grid north, magnetic north, true north.

(6) (b) azimuth circle.

(7) (c) 324°.

(8) A declination diagram is placed on most large-scale maps to enable the user to orient the map properly.

(9) (c) arc.

(10) added.

(11) On some large-scale maps, the annual magnetic change of the declination diagrams is so small its value is not shown on some standard large-scale maps.

(12) The standard compass used by the soldier in the field to measure direction and angle is the lensatic compass.

(13) When using the compass, one should keep away from metal objects and high-tension wires.

(14) On the lensatic compass, the north-seeking magnetic arrow always points to magnetic north.

(15) A pace is the average step used to measure distance. Each soldier should accurately measure his pace per 100 meters over a course of 100 meters for level terrain and 600 meters for cross-country.

(16) (c) oriented.

(17) (b) declination diagram

2-2. LEARNING ACTIVITY—OBJECTIVE 6

Upon completion of this learning activity, you will be able to explain how to orient a map using a compass and expedient methods.

a. Study Resources—Objective 6.

(1) Orientation of a map. Before a map can be used it must be oriented. This means that the map features must be aligned with those features on the ground. A map is said to be oriented when it is in a horizontal position with its north and south corresponding to north and south on the ground.

(a) A simple way to orient a map is with a compass.

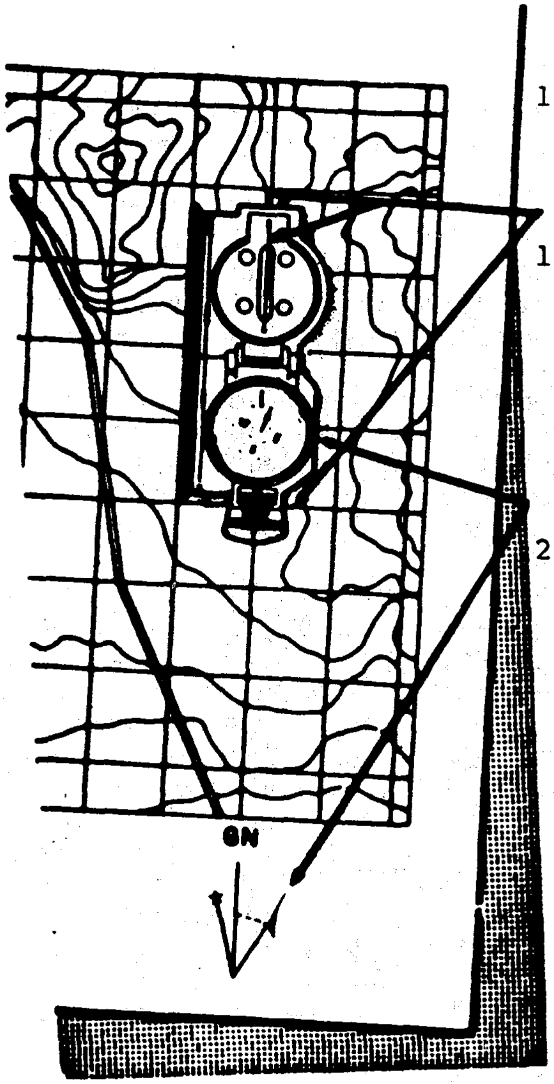
1 Step 1. Place the map in a horizontal position. The compass is placed parallel to a vertical grid line, with the cover side of the compass pointing toward the top (north) of the map.

2 Step 2. Align the black index line on the dial of the compass, parallel to grid north (grid lines on the map).

Note. A declination diagram on the face of the compass is formed by the index line on the compass and the compass needle.

3 Step 3. Rotate the map and compass until the directions of the declination diagram formed by the black index line and compass needle match the directions shown on the declination diagram. The map is then oriented (fig 2-13).

(2) If, after completing the above steps, the map feature and ground features are not aligned; check the compass for mechanical deficiencies. Repeat the orientation procedures.



1.a. Align straightedge of the compass with any vertical grid line.

1.b. Align sighting wire and notches at front and rear of compass over any north-south grid line. This places the index line on the face of the compass parallel to grid north.

2 Rotate map and compass together until the angle formed by the north needle and index line is the same value and relationship as shown for the G-M angle in the declination diagram in the map margin.

Figure 2-13. Map oriented with compass.

(b) Orienting a map by visual inspection.

1 To orient a map by visual inspection, at least two prominent features (such as A and B, fig 2-14) are needed for ground orientation.

2 Locate A and B on the map and on the ground; adjust the map until both ground features are aligned with the map symbols.

3 Locate your position. You can orient the map by aligning your plotted position with one additional prominent feature which is visible from your position and plotted on the map.

4 Orienting your map by visual inspection using a linear feature is slightly different. It is necessary to know the direction of the linear feature to avoid reversing the orientation.

If you cannot determine the direction of the linear feature, at least one additional prominent feature is needed to orient the map.

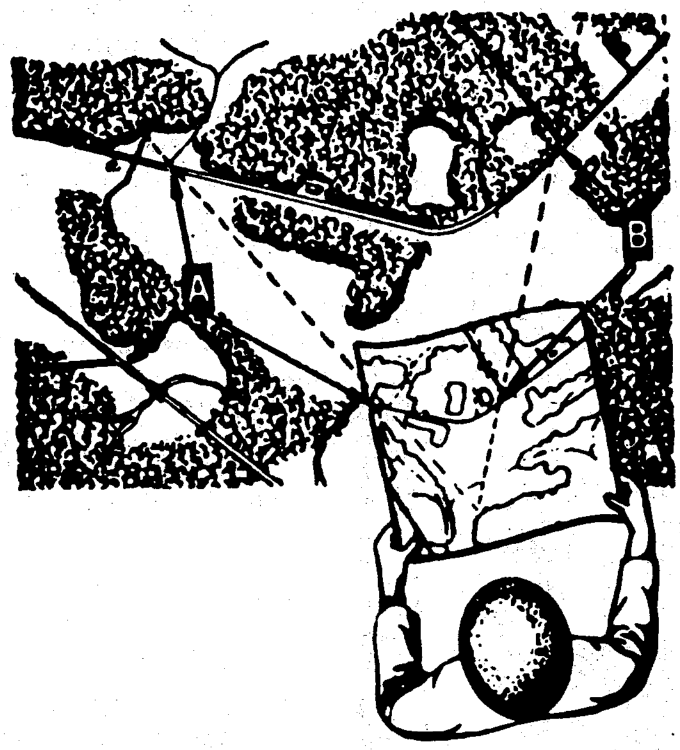


Figure 2-14. Orienting by visual inspection.

(c) A map is roughly oriented by determining the direction of true north. The top of a standard military map represents north. You can determine the approximate direction of north by various expedient methods such as the following:

1 Shadow-tip field expedient method.

a Step 1. Place a stick or branch into the ground vertically at a fairly level spot where a distinct shadow will be cast. Mark the shadow with a stone or some other object, such as a twig.

b Step 2. Wait about 10 or 15 minutes, until the shadow tip moves about five inches. Mark the new position of the shadow tip just as you did the first.

c Step 3. Draw a straight line through the two marks which were made on the shadow tips. This line is an east-west line (fig 2-15).

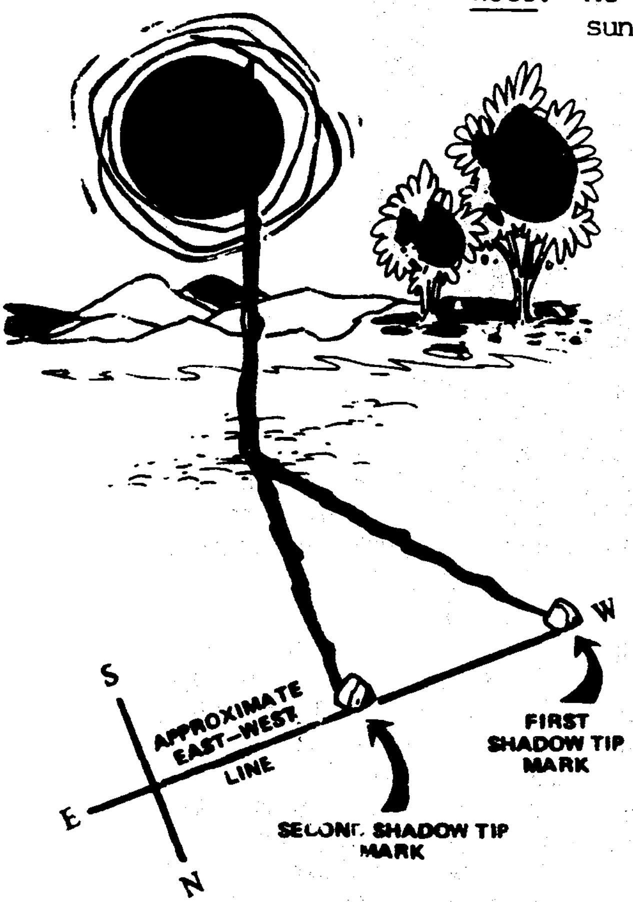
Note. It becomes necessary to tell which end of the line is east and which end is west.

d Step 4. Locate the first shadow tip mark you made and indicate west. The opposite end of the line is east. Remember that the sun rises in the east and sets in the west (generally). Therefore, the first shadow is always west.

e Step 5. To find the direction of north, turn your body until east is on your right and west is on the left. You will be facing north; south will be opposite of north.

f Step 6. Orient the map by aligning the N-S grid on the map with the general direction of true north.

Note. At 1200 hours standard time, the sun will almost be due south.



The sun always rises in the east and sets in the west, the shadow tip moves in just the opposite direction. So the first shadow tip mark you make is always WEST, and the second mark is always EAST.

Figure 2-15. Shadow-tip method.

2 Orienting by the watch field expedient method.

a You can orient your map by using a watch. This method is not as accurate as the shadow; however, it is accurate enough in the absence of a more precise method because of time or the enemy situation.

b If available point the hour hand of a watch towards the sun. South will be half way between the hour hand and twelve o'clock. Try this now using known directions.

c Once the direction of south is established, north is at the opposite end. Orient the map as discussed in paragraph 2a(1).

(1) If you are south of the equator (southern hemisphere) point twelve o'clock at the sun. Then half way between twelve o'clock and the hour hand is north.

(2) Remember, the sun moves on standard time. For example, if your watch is set on daylight savings time, south will be halfway between the hour hand and 11 o'clock.

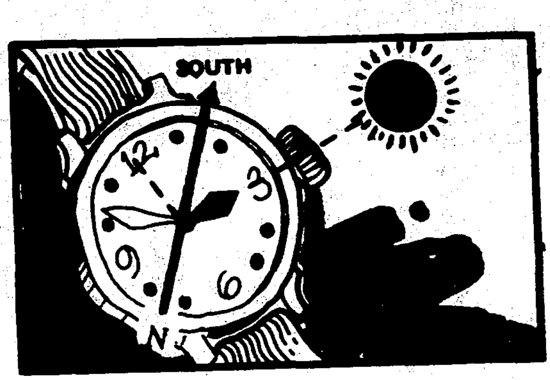


Figure 2-16,a. Watch field expedient method.

(d) Orienting a map at night. Because of the enemy situation, it may become necessary to travel at night, occasionally checking the map to be sure of the direction of travel. You can locate north at night with practice and an understanding of the position of certain stars.

1 Step 1. Find the Big Dipper (fig 2-16,b). The last two stars of the cup point directly at Polaris (the North Star).

2 Step 2. Divide the distance between Polaris and the stars in cup of the Big Dipper into equal measurements; from the top cup star, estimate seven times the distance between the two cup stars. The bright star you will see is Polaris.

3 Step 3. Face Polaris; you are facing north-east on the right, west to the left and south behind you.

4 Step 4. Orient your map.

Note. Artifical light is needed to see the map at night in a tactical situation. If this might compromise your location, use a poncho or other item to cover the light while reading the map.

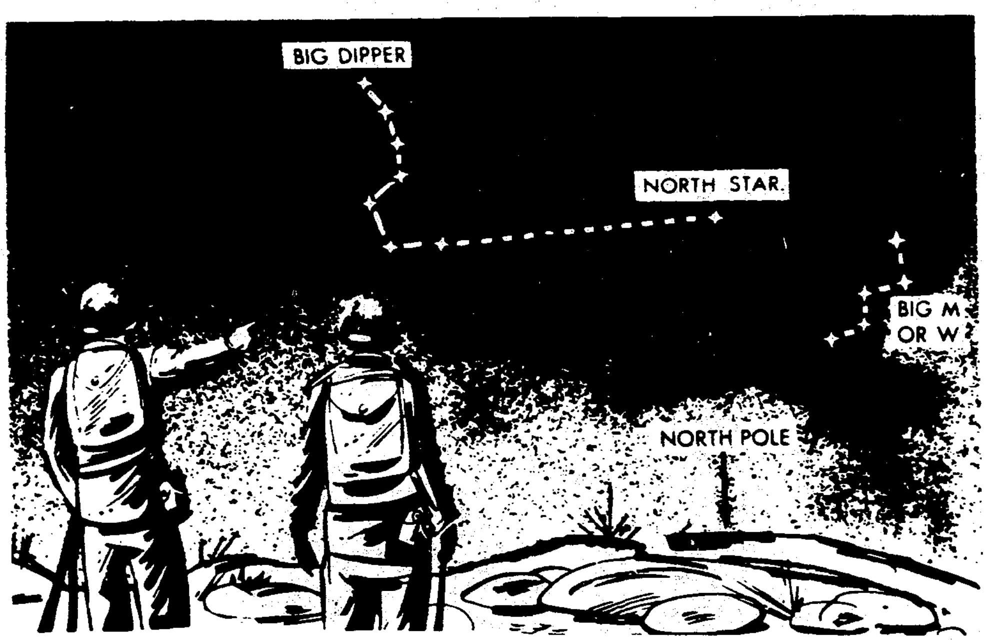


Figure 2-16,b. Night field expedient method.

Note. The distance from the cup star to polaris is 7 times the cup star distance instead of five times the distance as indicated in FM 21-26.

b. Practice Exercise—Objective 6.

(1) When orienting a map with a compass, the compass must be placed ________ to a north-south grid line.
 (a) parallel
 (b) perpendicular
 (c) horizontal
 (d) tangent

(2) To orient a map by visual inspection, at least ________ features are needed for ground orientation.
 (a) five
 (b) four
 (c) three
 (d) two

(3) The military map is roughly oriented by determining the direction of ____________.
 (a) magnetic north
 (b) grid north
 (c) true north
 (d) gradual north

(4) A field expedient method of orienting the map using the sun and shadow is known as the _______________ method.
 (a) sun-tip
 (b) sun-shadow
 (c) solar-tip
 (d) shadow-tip

(5) It may become necessary to orient the map at night. The name of the star formation to look for is the ____________.
 (a) Big Apple
 (b) Big Star
 (c) Big Dipper
 (d) Big Cup

(6) Another name for Polaris is the ____________.
 (a) North Star
 (b) North Dipper
 (c) North Way
 (d) North Cup

(7) A map is oriented using the field expedient method when the ____________ grid on the map is aligned with the general direction of ___________ north.
 (a) vertical true
 (b) horizontal magnetic
 (c) vertical magnetic
 (d) horizontal true

c. <u>Solutions to Practice Exercise -- Objective 6.</u>

(1) (a) parallel
(2) (d) two
(3) (c) true north
(4) (d) shadow-tip
(5) (c) Big Dipper
(6) (a) North Star
(7) (a) vertical true

LESSON THREE

OBJECTIVE: Task No. To be determined.

TASK: Upon completion of this lesson, you will understand how to: locate unknown points on the topographic map; find your location when lost, use a linear symbol to locate unknown positions on a map, measure elevation and relief, and construct intervisibility profiles to determine the ability of the observer to observe terrain in a given sector on the map.

CONDITIONS: You will have Subcourse Booklet AR0120 and an examination response sheet. You will work at your own pace and in your own selected environment with no supervision.

STANDARDS: Within approximately three hours you should be able to study the lesson, answer the practice exercise questions, and select the correct response for each examination question. You must respond correctly to 75 percent of the questions in order to receive credit for the subcourse.

CREDIT HOURS: 3.

REFERENCES: FM 21-26, "Map Reading" and FM 21-31, "Topographical Symbols."

3-1. LEARNING ACTIVITY--OBJECTIVE 7

Upon completion of this learning activity, you will understand how to locate unknown points on a map, find your location when you are lost, and use a linear feature to locate unknown positions on a map.

Note: For the purpose of understanding problems in this section, do not consider elevation and relief, terrain profiles, any form of intervisibility, or observation-line-of-sight. These methods will be taught later in the subcourse.

a. Study Resources--Objective 7.

(1) Intersection.

(a) The location of an unknown point by obtaining azimuths from two or more points or by successively occupying at least two positions (preferably three) and sighting on the unknown point is called intersection. It is used to locate features that are not defined on a map or which are not readily identifiable. The two methods of intersection are the map-and-compass method and the straightedge method.

(b) Map and compass.

1 Step 1. Orient the map using the compass.

Note. Map need not remain oriented during the remaining steps.

2 Step 2. Locate and mark your position on the map.

3 Step 3. Measure the magnetic azimuth to the unknown position; convert the magnetic azimuth to a grid azimuth.

4 Step 4. Draw a line on the map from your position on this grid azimuth to an estimated distance of the unknown location.

5 Step 5. Move to a second known position from which the unknown point is visible or obtain another azimuth from a nearby unit. Locate this point on the map and reorient the map using the compass.

6 Step 6. Measure the magnetic azimuth to the unknown position. Again, convert the magnetic azimuth to a grid azimuth.

7 Step 7. Draw a line on the map from your position on this grid azimuth until this line and the line previously drawn crosses or intersects. Where these two lines intersect is the position on the map and the ground of the previously unknown position (fig 3-1). The more nearly a right angle is formed by these intersecting lines, the more accurate will be your position.

8 Step 8. For greater accuracy, a third known position is sometimes used. When the third position is used, compute the azimuths and draw the lines as indicated above.

Note. Refer to the Vine Grove map and use the coordinate scale protractor shipped with this subcourse.

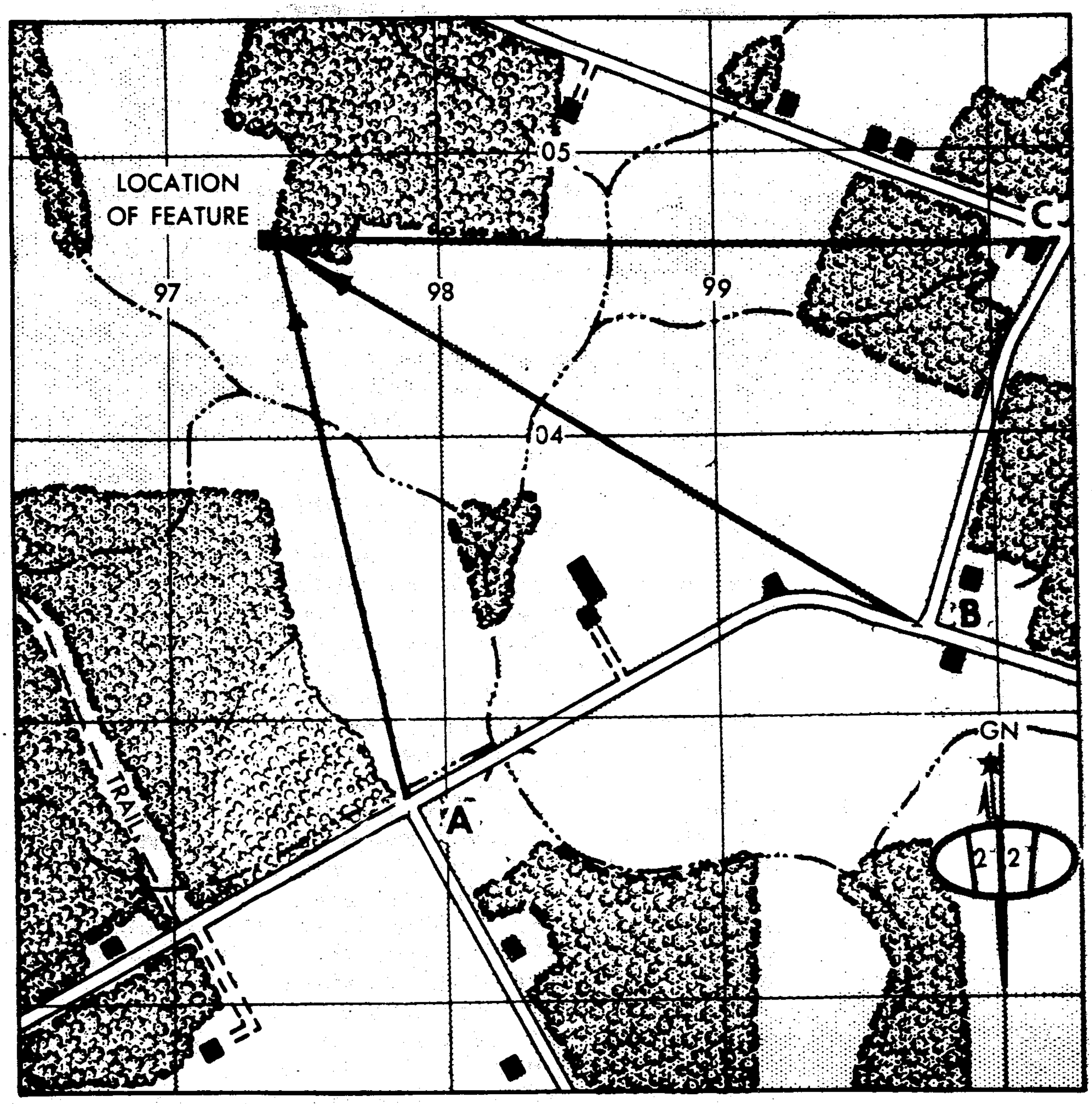


Figure 3-1. Intersection.

Note: See figure 3-2 to solve the problem below.

(c) Problem: You are on OP 1 at spot elevation 232 in grid square ET 0202. You observe a helicopter fall from the sky and burn on a magnetic azimuth of 21°. OP 2 in grid square ET 0502, spot elevation 244 called you on the radio and stated that the same crash was observed on a magnetic azimuth of 344°.

What is the location of the helicopter within 100 meters (six-digit coordinate)?

1 Step 1. Orient the map using a compass or field expedient method.

Note. Map need not remain oriented during the remaining steps.

2 Step 2. The magnetic azimuth is given in the problem (21°). To convert a magnetic azimuth to a grid azimuth on the Vine Grove map, subtract the G-M angle. The G-M angle is 1° ($1/2^{\circ}$ rounded off to 1°). Therefore, the grid azimuth is 20°.

3 Step 3. Convert the magnetic azimuth of 21° to a grid azimuth of 20° and plot this azimuth on your map. (From your location.)

4 Step 4. Draw a line on the map from spot elevation 232 (ES0202) on a grid azimuth of 20° to the length of the coordinate scale.

5 Step 5. The second azimuth can be obtained by moving to another location. However, in this case you have radio contact with the OP at spot elevation 244. By radio you obtain a magnetic of 344°. Locate spot elevation 244 in grid square ET 0502.

6 Step 6. Determine the azimuth from spot elevation 244 to the unknown position; don't forget to change the magnetic of 344° to a grid azimuth of 343°.

7 Step 7. Draw a line from spot elevation 244 to the unknown position. The point where the drawn azimuth lines intersect is the location of the crashed helicopter (fig 3-2).

8 Step 8. You monitor a report from the patrol located at ET 07310420, who called in the location of the crash, on a grid azimuth of 300°. Plot this azimuth on your map; do not convert this azimuth because it was given as a grid azimuth. Therefore, it can be quickly plotted on the map for greater accuracy and a recheck of the previous azimuth. Plot the six-digit coordinate to the intersection of the three lines on the map.

ANSWER: ET 044059

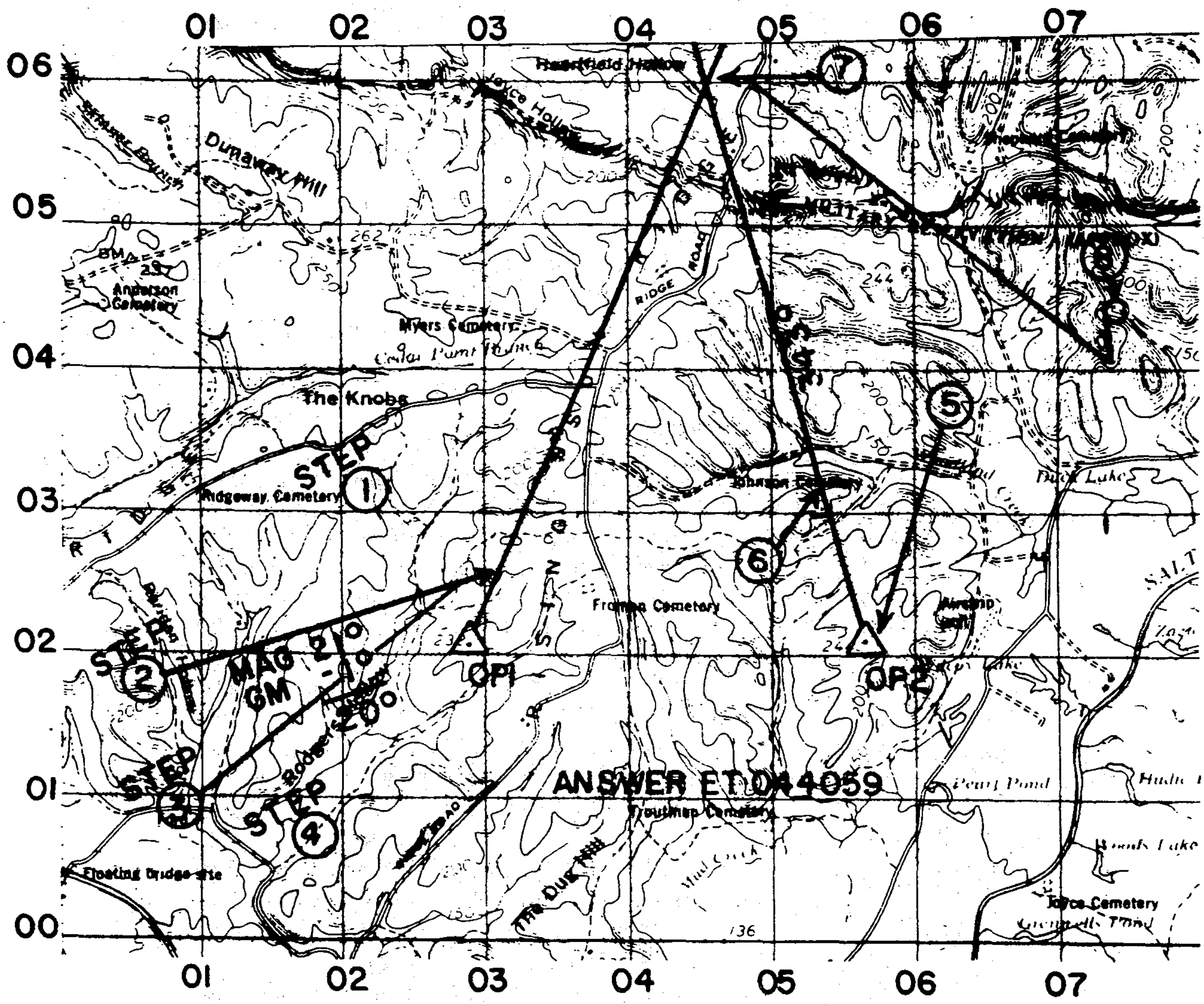


Figure 3-2. Intersection problem and solution.

(d) Straightedge method (when no compass is available).

1 Step 1. Orient the map by visual inspection (fig 2-14).

Note. The map need not remain oriented during the remaining steps.

2 Step 2. Locate and mark your position on the map.

3 Step 3. Lay a straightedge on the map with user's end position (A) as a pivot point. Rotate the straightedge until the unknown point is sighted along the edge.

4 Step 4. Draw a line along the straightedge.

5 Step 5. Repeat step 1-4 at position B and, for a check of accuracy, at a third position.

6 Step 6. The intersection of the lines is the location of the previously unknown point (C) (fig 3-3).

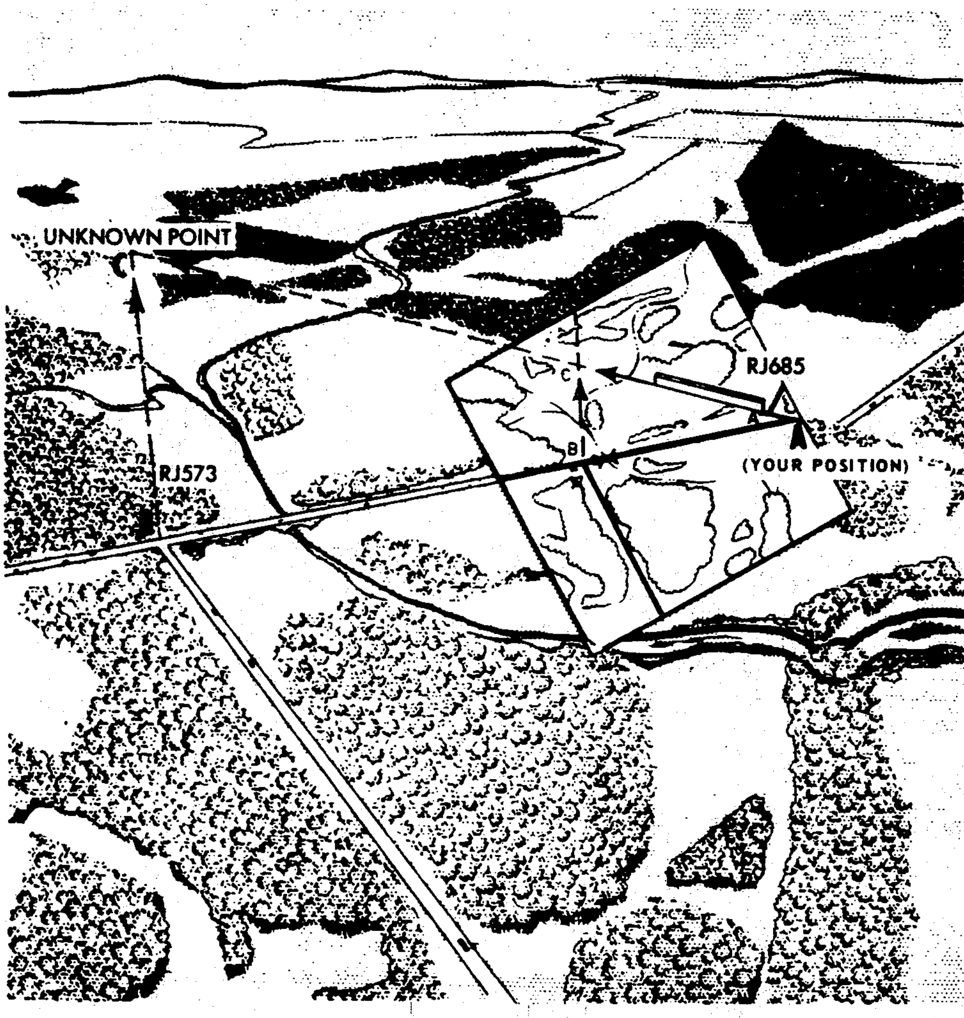


Figure 3-3. Intersection without a compass.

(2) Resection.

(a) Locating your position by sighting on two known features is known as resection. The location of the user's unknown position by sighting on two or three known features can be done with or without a compass.

1 Step 1. Orient the map using the compass.

Note. Map need not remain oriented during the remaining steps.

2 Step 2. Identify two prominent terrain features (A and B) and locate these features on your map.

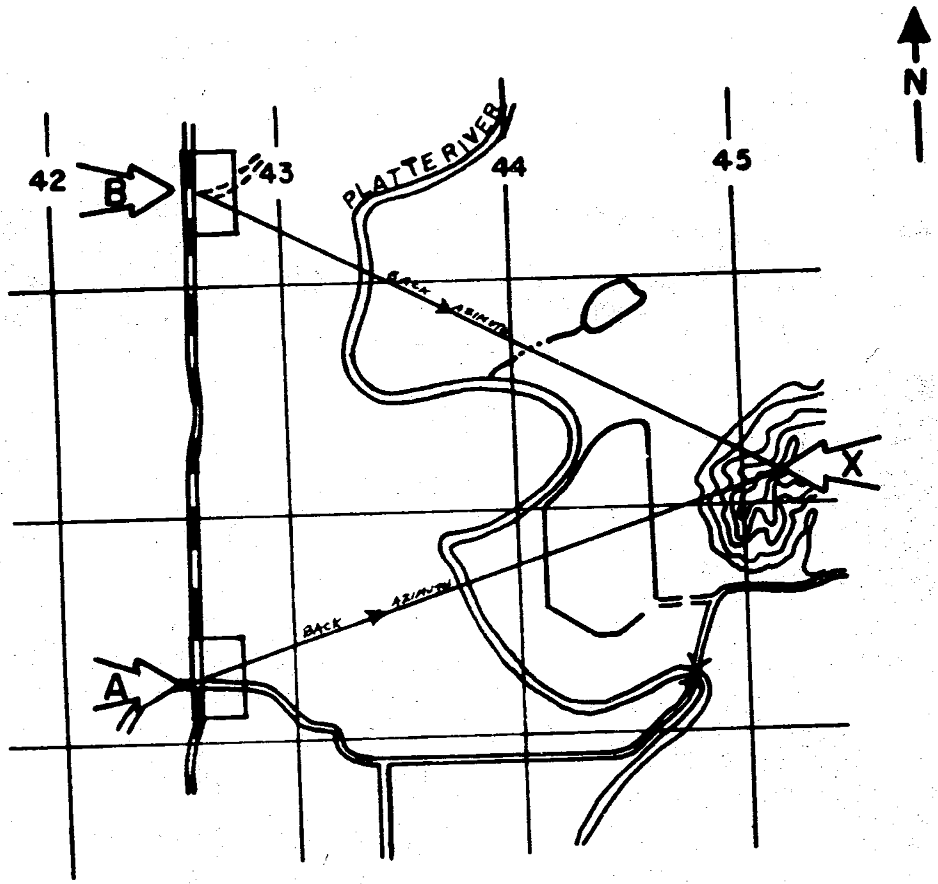


Figure 3-4. Resection with a compass.

3 Step 3. Take compass sightings on features A and B; convert to grid azimuth.

4 Step 4. Plot back azimuth (grid) from point A and point B toward your position on the map.

5 Step 5. Intersection of the back azimuths on your map pinpoints your previously unknown position (X).

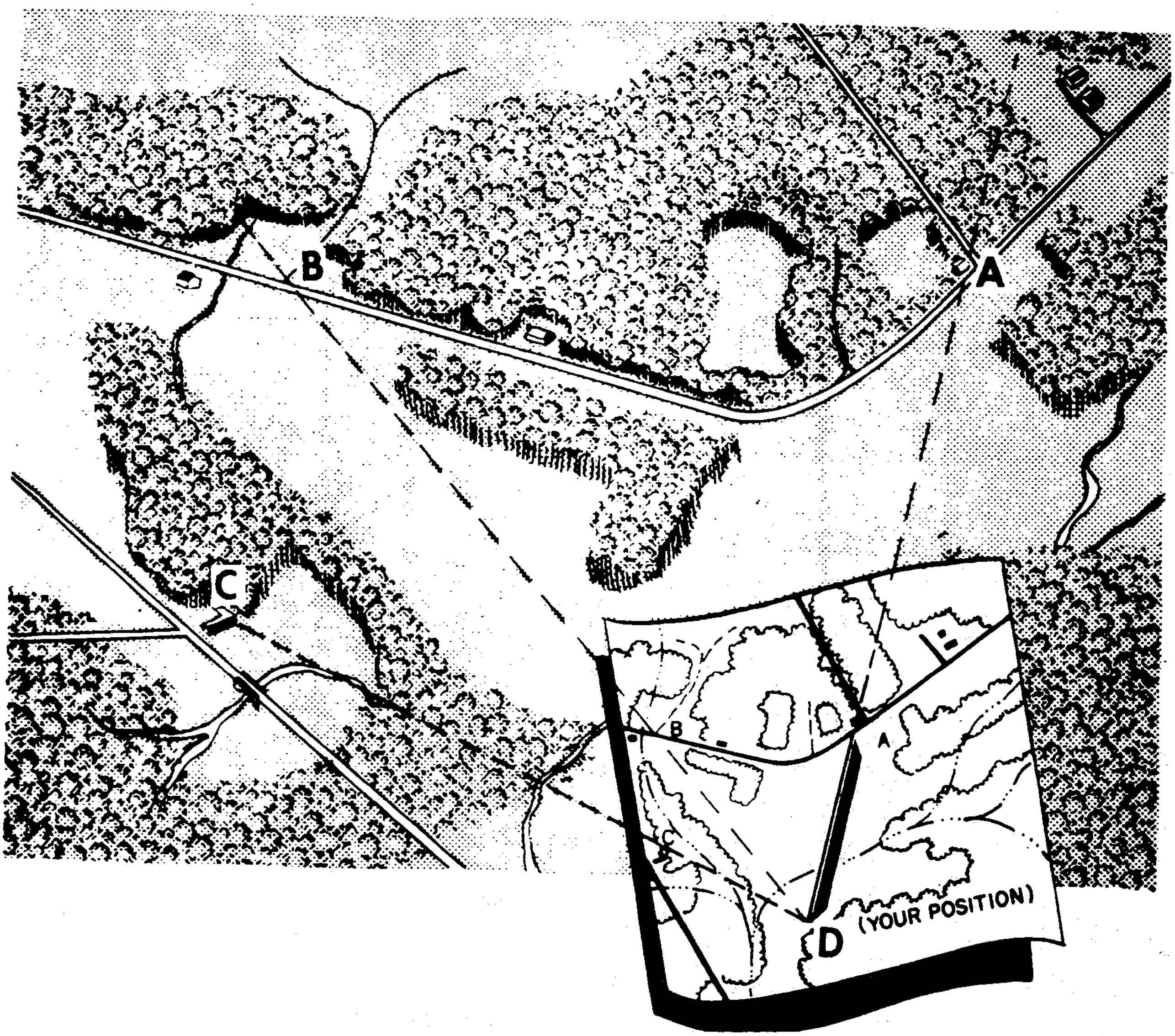


Figure 3-5. Resection straightedge method.

(b) Problem. You are lost! From a study of the elevation guide and a detail map study, you determined that you are located on one of several ridges in the Glenn Meadows area in the vicinity of Mud Creek. Orienting the map to north, you now determine through the use of terrain association that spot elevation 244 on a magnetic azimuth of

38° is on your right and spot elevation 232 on a magnetic of 297 degrees is on your left. What is the six-digit coordinate to your location?

1 Step 1. Orient the Vine Grove map using a compass or field expedient method.

Note. Map need not remain oriented during the remaining steps.

2 Step 2. Locate spot elevation 244 in grid square ET 0502. Now, locate the second terrain feature, spot elevation 232 in grid square ET 0202 on a magnetic azimuth of 297° degrees.

3 Step 3. Remember, you have a compass sighting of 38° for spot elevation 244. Change this magnetic azimuth to a grid azimuth by subtracting the G-M angle (1°). Convert to a back azimuth. Since 38° is less than 180°; 180° is added to 38° for 217° back azimuth. The back azimuth for the second spot elevation 232 is 116°, since 297° minus 180° is 117° minus G-M angle of 1°. 297° is greater than 180°, therefore 180° is subtracted from 297°.

4 Step 4. Plot the back azimuths and observe where the lines intersect.

Note. The back azimuth must be plotted for 38° and 297°. The GM angle of 1° is subtracted from the original magnetic azimuth.

5 Step 5. The intersection of the back azimuths on your map pinpoints your previously unknown position.

Answer: ET 049011.

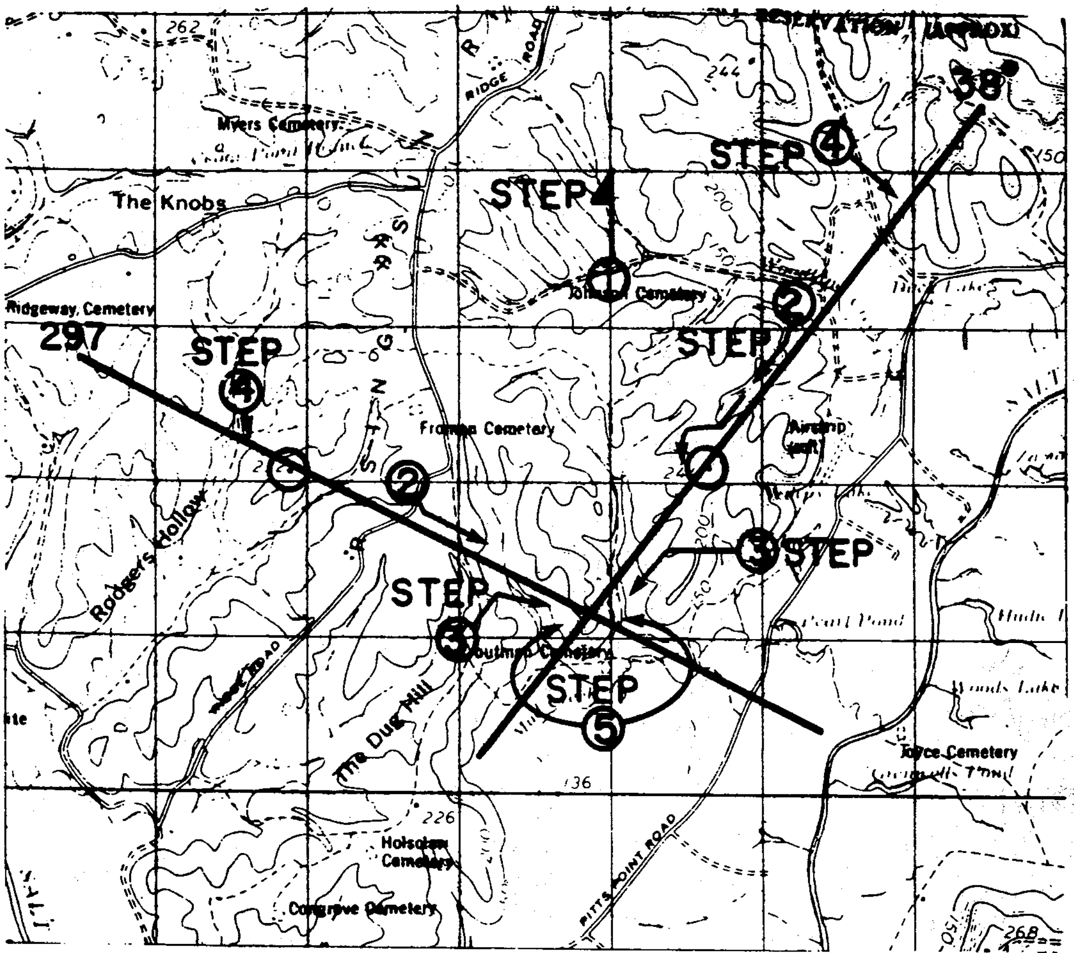


Figure 3-6. Resection problem and solution.

(3) Modified resection (linear feature).

(a). If you are located somewhere along a certain linear feature on the map (such as a road or river bank), use modified resection to pinpoint your location.

1 Step 1. Orient your map using a compass.
Note. Map need not remain oriented during the remaining steps.

2 Step 2. Locate a topographical symbol on the ground that you can identify on the map.

3 Step 3. Place a straightedge through the topographical symbol or shoot an azimuth to the symbol and draw a back azimuth. Convert the magnetic azimuth to grid and compute the G-M angle.

4 Step 4. Measure the point of intersection of the line and the linear feature. This point marks the position of your previously unknown location.

(b) Problem: You are floating down the Salt River on a raft and you wish to know your location. The raft is moving generally south; you recognize the airstrip (soft) on your right (west). What is the location of your position within 200 meters?

1 Step 1. Orient your map using a compass (locate south).

Note. Map need not remain oriented during the remaining steps.

2 Step 2. Locate the airstrip (soft) in grid square 16SET0602 on your map.

3 Step 3. Determine an azimuth to the center of the airstrip. The azimuth is 271° magnetic. Convert the magnetic to grid and compute the GM angle.

4 Step 4. Use the coordinate scale protractor to measure the point of intersection of the river and the drawn line.

Answer: ET 075022.

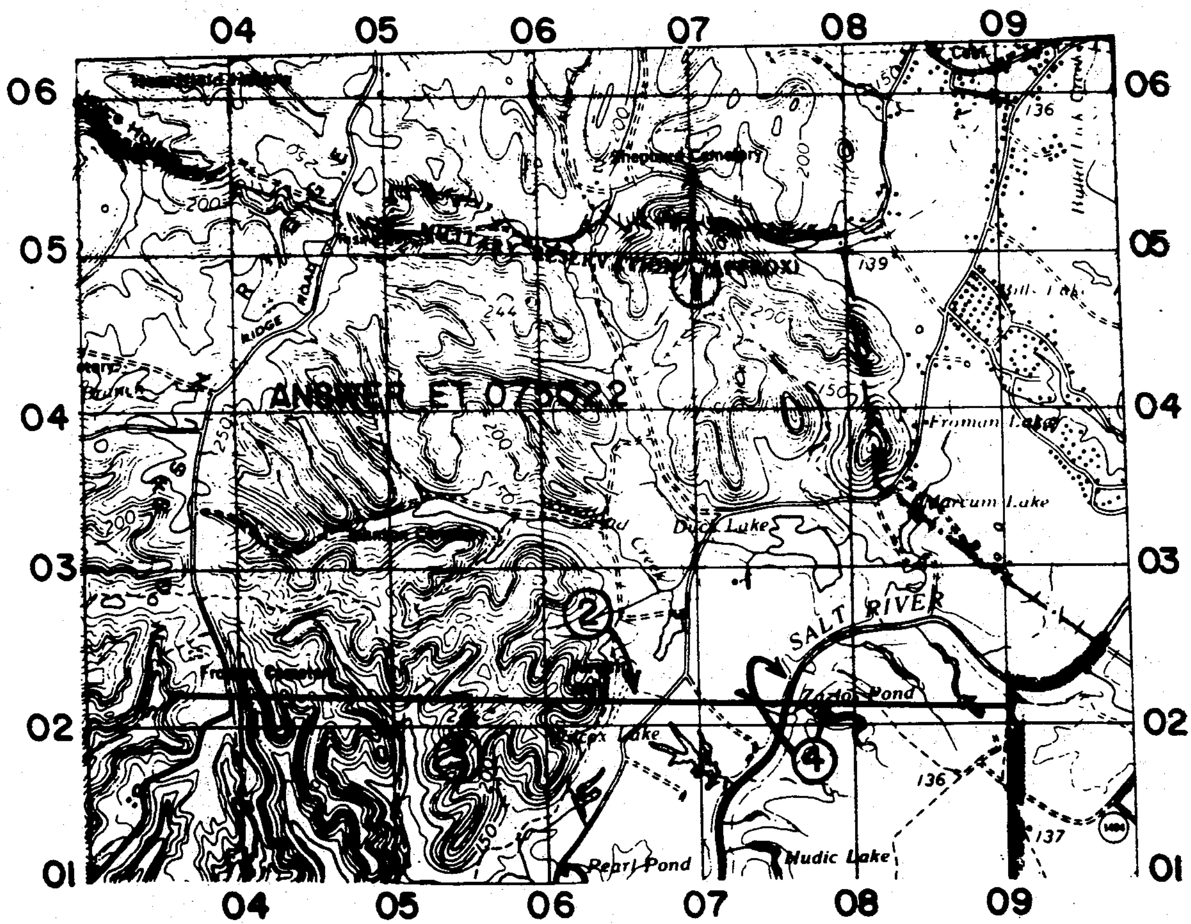


Figure 3-7. Modified resection.

b. Practice Exercise — Objective 7.

(1) Determining the location of an unknown point by obtaining azimuths from at least two positions is known as ______________.
   (a) interjection.
   (b) resection.
   (c) intersection.
   (d) by-section.

(2) To solve intersection problems, the first suggested step is usually map ____________.
   (a) orientation.
   (b) inspection.
   (c) declination.
   (d) inclination.

(3) When solving intersection problems, the G-M angle is
   (a) insignificant.
   (b) considered.
   (c) subtracted.
   (d) added.

(4) Locating your position by determining azimuths to two known features is known as
   (a) orientation.
   (b) inspection.
   (c) inclination.
   (d) resection.

(5) The first suggested step in resection is to orient the map using the
   (a) declination diagram.
   (b) compass.
   (c) G-M angle.
   (d) modified resection.

(6) The example of modified resection in this subcourse requires a
   (a) complete G-M angle.
   (b) computation of angular differences.
   (c) linear feature.
   (d) pinpoint angle.

(7) To successfully determine your location using modified resection, the forward azimuth must be changed to a
   (a) declination diagram.
   (b) back azimuth.
   (c) magnetic azimuth.
   (d) azimuth indicator.

c. <u>Solutions to Practice Exercise--Objective 7</u>.

(1) (c) intersection.
(2) (a) orientation.
(3) (b) considered.
(4) (d) resection.
(5) (b) compass.
(6) (c) linear feature.
(7) (b) back azimuth or magnetic.

3-2. LEARNING ACTIVITY—OBJECTIVE 8

Upon completion of this learning activity, you will be able to measure elevation and understand how relief features are associated with elevation.

a. Study Resources—Objective 8.

(1) A knowledge of map symbols, grids, scale, and distance gives enough information to identify, locate, measure between, and determine how long it would take to travel between two points. But what happens if there should be a 300-foot cliff between the two points? The map user must also become proficient in recognizing the various land forms and irregularities of the earth's surface. He must be able to determine the elevation and differences in height of all terrain features.

(a) Datum plane. This is a reference from which vertical measurements are taken. The datum plane for most maps is the average sea level.

(b) Elevation. This is defined as the height (vertical distance) of an object above or below a datum plane.

(c) Relief. Relief is the representation of the shape and height of land forms and the characterization of the earth's surface.

(2) The elevation of points and the relief of an area affect the movement and deployment of units. Elevation and relief limit the route along which units may travel, their speed of movement, and the ease or difficulty of attack or defense. Also affected are observation, fields of fire, cover, concealment, and the selection of key terrain features.

(3) Contour lines.

(a) There are several ways to indicate elevation and relief on maps. The most common way is by contour lines. A contour line represents an imaginary line on the ground along which all points are at the same elevation.

(b) Contour lines indicate a vertical distance above or below a datum plane. Starting at sea level, normally the zero contour, each contour line represents an elevation above sea level. The vertical distance between adjacent contour lines is known as the contour interval. The amount of the contour interval is given in the marginal information. On most maps, the contour lines are printed in brown. Starting at zero elevation, every fifth contour line is drawn with a heavier line. These are known as index contours. Someplace along each index contour the line is broken and its elevation is given. The contour lines falling between index contours are called intermediate contours. They are drawn with a finer line than the index contours and usually do not have their elevations given.

(c) Using the contour lines on a map, the elevation of any point may be determined by

1 Finding the contour interval of the map from the marginal information and noting both the amount and the unit of measure.

2 Finding the numbered contour line (or other given elevation) nearest the point for which the elevation is being sought.

3 Determining the direction of slope from the numbered contour line to the desired point.

4 Counting the number of contour lines that must be crossed to go from the numbered line to the desired point and noting the direction—up or down. The number of lines crossed multiplied by the contour interval is the distance above or below the starting value.

a If the desired point is on a contour line, its elevation is that of the contour.

b For a point between contours, most military needs are satisfied by estimating the elevation to an accuracy of one-half the contour interval (fig 3-8). All points less than one-fourth the distance between all lines are considered to be at the same elevation as the line. All points one-fourth to three-fourths the distance from the lower line are considered to be at an elevation one-half the contour interval above the lower line. If a more precise determination of elevation is needed, or if the contours are very widely spaced, the elevation of the point may be interpolated to the accuracy desired.

c To estimate the elevation of the top of an unmarked hill, add half the contour interval to the elevation of the highest contour line around the hill.

d To estimate the elevation of the bottom of a depression, subtract half the contour interval from the value of the lowest contour around the depression.

(d) On maps where the index and intermediate contour lines do not show the elevation and relief in as much detail as may be needed, supplementary contours may be used. These contour lines are dashed brown lines, usually at one-half the contourh interval for the map. A note in the marginal information indicates the interval used. They are used exactly as are the solid contour lines.

(e) On some maps, the contour lines may not meet the standards of accuracy as specified, but are sufficiently accurate in both value and interval to be shown as contours rather than as form lines. In such cases, the contours are considered approximate and are shown with a dashed symbol; elevation values are given at intervals along the heavier (index contour) dashed lines. The contour note in the map margin identifies them as approximate contours.

(f) In addition to the contour lines, bench marks and spot elevations indicate points of known elevation on the map. Bench marks, the more accurate of the two, are symbolized by a black X, as X BM 124. The elevation value shown in black refers to the center of the X. Spot elevations shown in brown generally are located at road junctions and are the map-maker's estimation of elevation. Spot elevation with the numerals in black are measured..

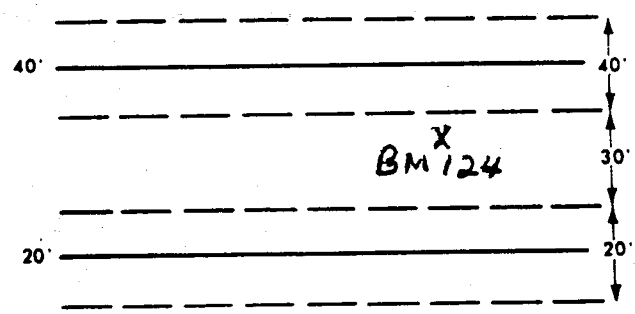


Figure 3-8. Estimating elevations between contour lines.

(g) To show the relationship of actual terrain to contour lines, figure 3-9 thru figure 3-13 show a picture and the contour lines.

1 Contour lines which are evenly spaced and wide apart indicate a uniform gentle slope (fig 3-13).

2 Contour lines which are evenly spaced and close together indicate a uniform steep slope. The closer the contour, the steeper the slope (fig 3-9).

3 Contour lines which are closely spaced at the top and widely spaced at the bottom indicate a concave slope (fig 3-11 and 3-13). Considering relief only, an observer at the top of a concave slope can observe the entire slope and terrain at the bottom. Conversely, a unit attacking up such a slope would have no cover or concealment from observers or weapons at or near the top. Also, the further up the slope, the more difficult the climb.

4 Contour lines which are widely spaced at the top and closely spaced at the bottom indicate a convex slope (fig 3-12). An observer at top of a convex slope has no observation of most of the slope or the terrain at the bottom. Conversely, a unit attacking up such a slope has a much greater degree of cover and concealment than on a concave slope; also, the further up the slope, the easier the climb.

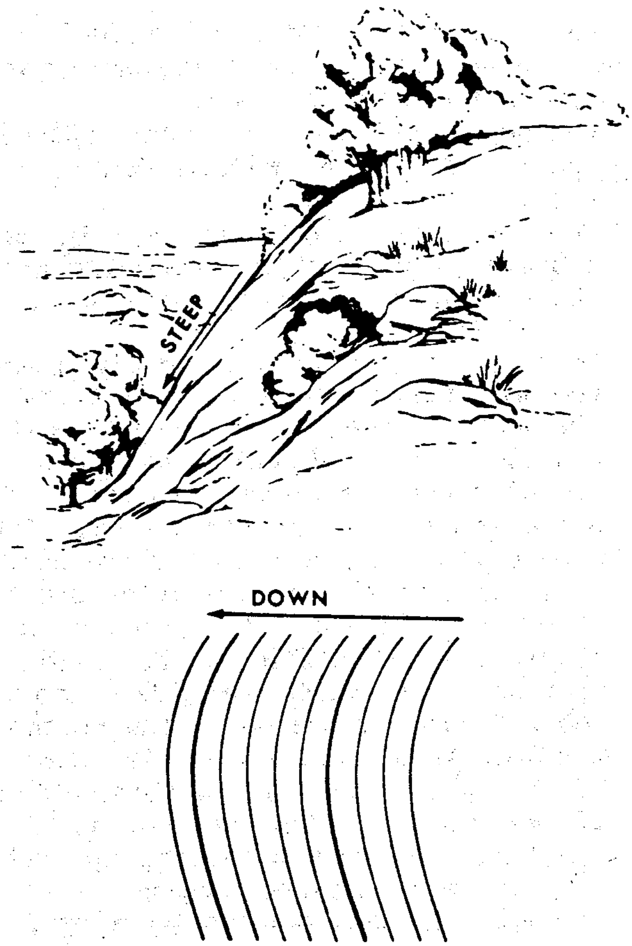


Figure 3-9. Uniform steep slope.

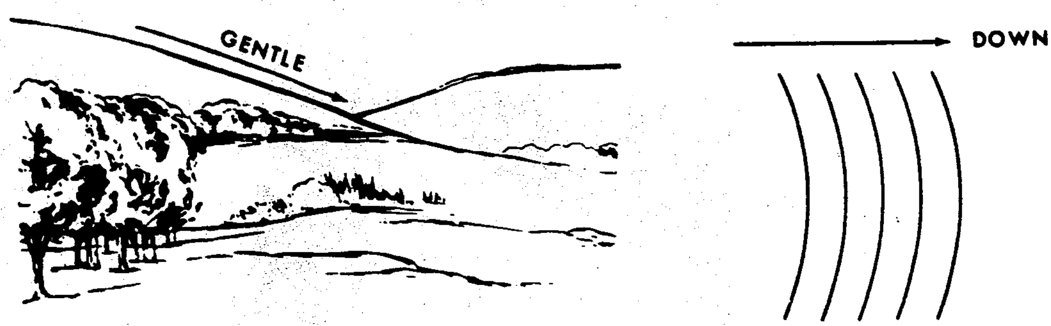


Figure 3-10. Uniform gentle slope.

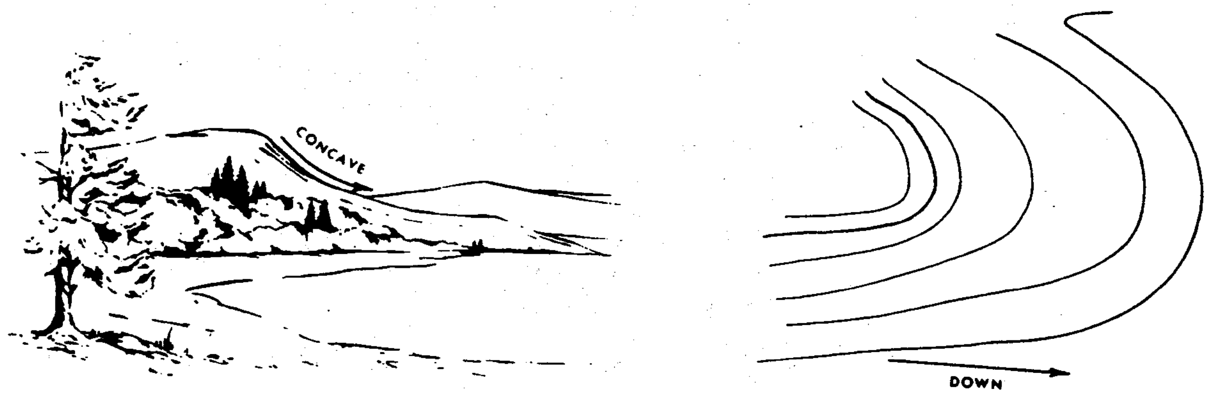


Figure 3-11. Concave slope.

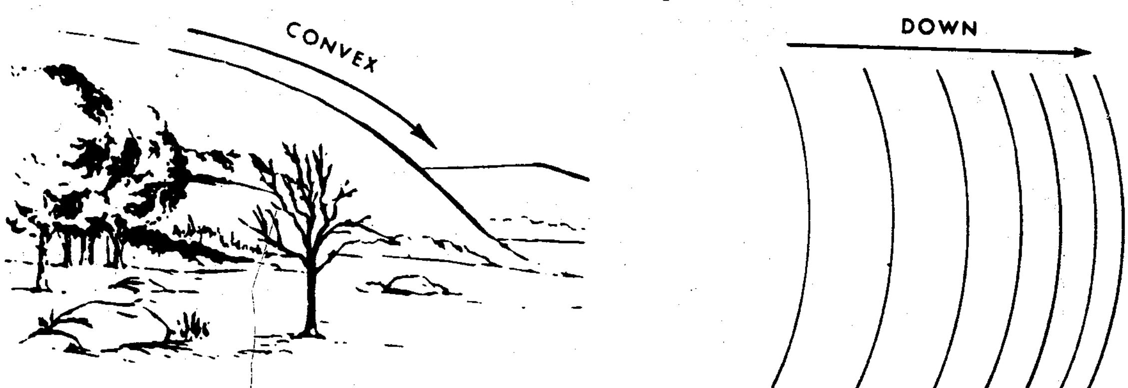


Figure 3-12. Convex slope.

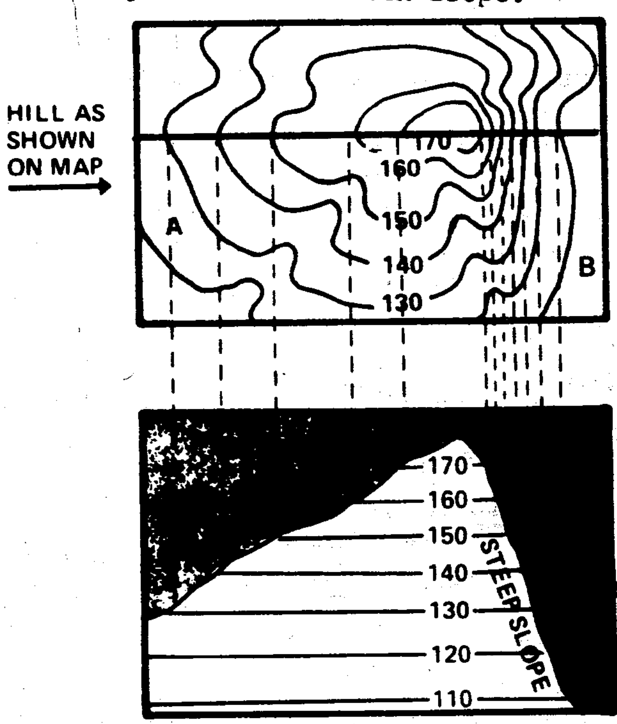


Figure 3-13. Measuring slopes.

(h) How to determine elevation of a point.

1. Look at the contour lines on the map. Check the contour interval--the difference in height (elevation) between one brown line and the one next to it (fig 3-15).

2. Every fifth line is numbered and heavier than the rest and has a number that gives its elevation. Locate the heavy contour line in figure 3-14. If the contour interval is 20 feet, the height or elevation of point (A) from point (B) is 80 feet. If the contour interval was 10 feet, the height from (B) to (A) is 40 feet.

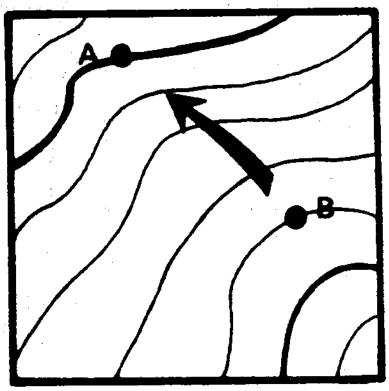


Figure 3-14. Contour interval.

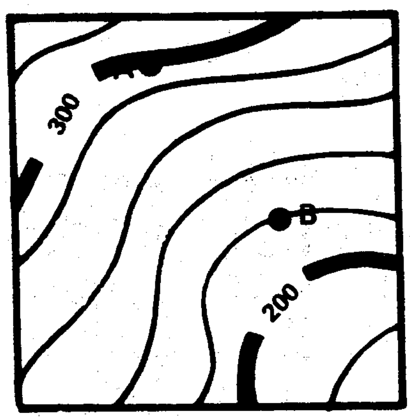


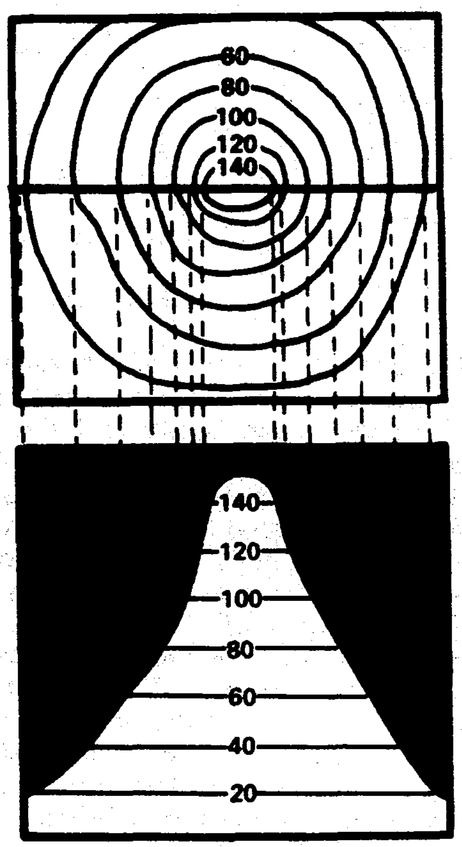
Figure 3-15. Numbered contour.

3. To find the elevation or height of any point, count the number of contour lines between the two points from the heavy contour line. Count upward or downward depending on the location of the points. If the point falls directly on a contour line, the elevation is the number in feet of the contour line. If, however, the point is between the contour lines, the height is one half the value of the contour. The enclosed contour at the top of a hill is given the value of that contour line (enclosed), plus one-half of the value of the contour interval. For example, a point on a hilltop is said to be 400 feet to the last enclosed contour. The height of the hilltop is 400 feet plus 10 feet, if the contour interval of the map is 20 feet.

4. A depression is measured in much the same manner as elevation, except the contour lines are subtracted until the last enclosed contour

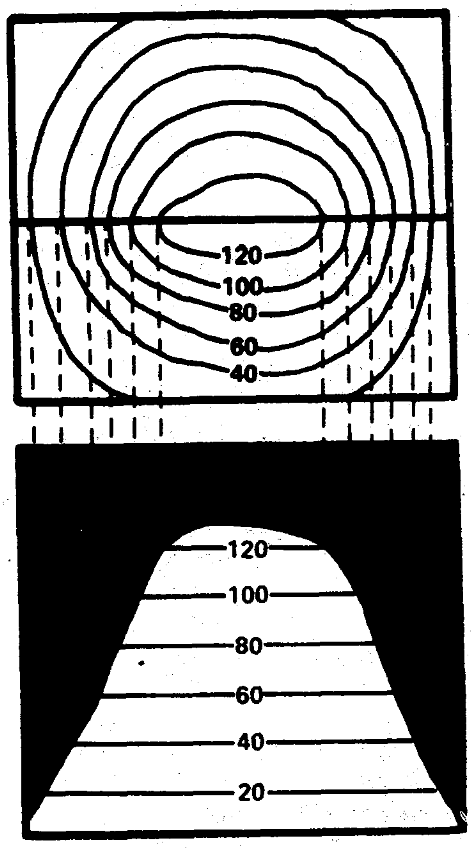
is reached. The initial depression contour line takes the value of the nearest lower standard contour line. Subtract one-half of the contour interval from the last enclosed contour of the depression to get the depth of the depression.

5 When the contour lines are close together at the top of the hill (fig 3-16), the hilltop is pointed. The hilltop is flat when the contour lines are widely spaced at the top (fig 3-17).



THE ENCLOSED CONTOUR AT THE TOP OF A HILL IS GIVEN THE VALUE OF THE CONTOUR PLUS ONE-HALF OF THE CONTOUR INTERVAL.

Figure 3-16. Steep hilltop.



THE SAME COMPUTATION IS USED FOR DETERMINING THE HEIGHT OF FLAT HILLS AS USED FOR STEEP HILLS SEE FIG 3-16.

Figure 3-17. Flat hilltop.

1 Elevating slopes. Determination of slope is critical to you as an armor soldier. You must be able to determine if your element will be able to travel a given route. This determination will frequently revolve around two critical factors - streams or similar obstacles and/or slope. A slope is any deviation, slant, or incline from the horizontal.

2 In the field, there are a number of factors which can drastically lower this capability to a practical level of around 40 percent.

a Driver skill--How well a person can drive the particular vehicle involved.

b Engine/drive train wear--How many hours that vehicle has been used.

c Soil trafficability--Mud or sand.

d Vegetation--large trees, thick growth, small trees, or grass (particularly if wet).

e Rocks or gravel on the slopes.

f Actual combat load or overload.

g Speed of vehicle when negotiating a slope.

h The length of slope.

(j) To determine the percent-of-slope accurately, one must actually be on the slope and use one of several measuring devices. There is, however, a way to obtain an approximate percent-of-slope without actually being on the slope (fig 3-18).

1 To obtain an approximate percent-of-slope, you need two parameters, one being the vertical distance (VD) and the other the horizontal distance (HD) of the slope in question.

2 Once these values have been obtained, simply apply the following mathematical formula: Vertical distance times 100 divided by the horizontal distance, or $\frac{VD \times 100}{HD}$.

Question: You are at an elevation of 300 meters. You propose to climb up a slope to an elevation of 500 meters, a vertical distance of 200 meters (500-300 = 200). The horizontal distance is 1,000 meters. What is the approximate percent-of-slope?

Answer: 20% (200 x 100 = 20000 ÷ 1000 = 20).

Question: You are at an elevation of 300 meters. You propose to climb up a slope to an elevation of 460 meters. The horizontal distance is 400 meters. What is the percent-of-slope?

Answer: 40% (160 x 1000 = 16000 ÷ 400 = 40).

Question: What is the percent-of-slope from point A to point B on the drawing (see fig 3-18)?

a. Point A is at an elevation of 710 meters.
b. Point B is at an elevation of 725 meters.
c. The vertical distance is 15 meters.
d. The horizontal distance is 1,500 meters.

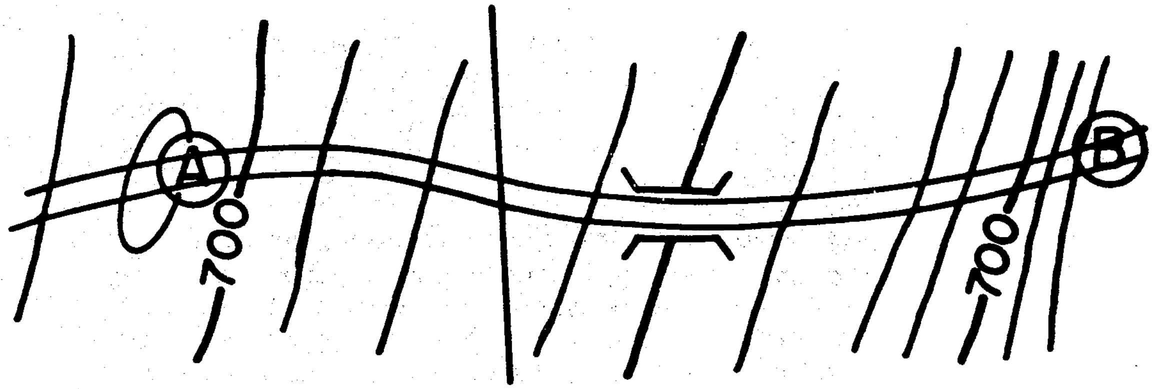


Figure 3-18. Percent of slope.

Is the percent-of-slope 1 percent?

No. You must determine the steepest slope on the route. These slopes will usually be no more than 100 to 500 meters in horizontal distance. Here is pertinent data for the steepest slope on the route (fig 3-19):

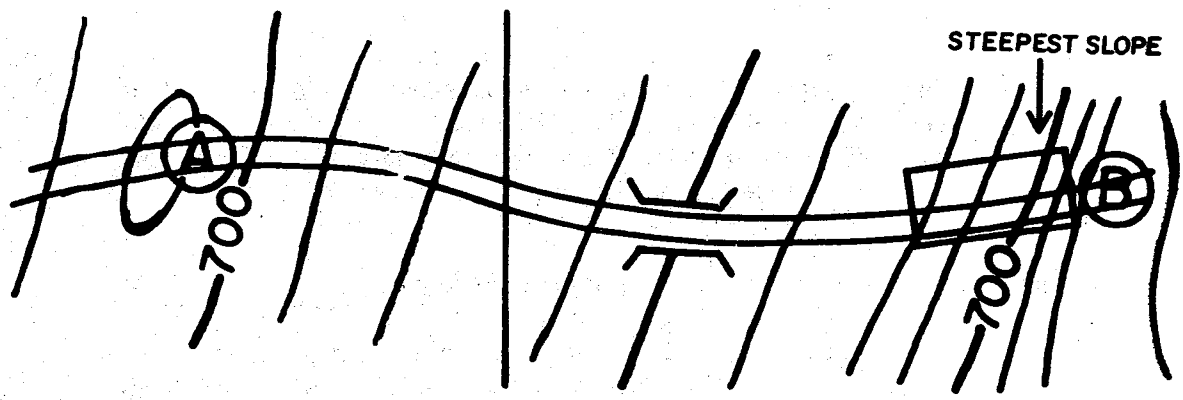


Figure 3-19. Recomputation of Percent-of-slope.

- vertical distance (40 meters).
- horizontal distance (250 meters).

Answer: The percent-of-slope is 16 percent.

The vertical distance must be extracted from the contour lines of the map. The horizontal distance must be measured along the road or designated route for only the steepest portion.

Remember, only an approximate percent-of-slope can be obtained from the map. Concern yourself with the steepest slope(s) that must be climbed. Slopes that must be descended are not so critical. A 60-percent slope will seldom offer any serious obstacles to descent, while 60-percent uphill slopes are usually significant obstacles. An uphill slope on your route is called a positive slope. The percentage is preceded by a plus sign (+16 percent for the answer above). A downhill slope is called a negative slope, and is indicated by placing a minus sign before the percentage.

<u>Notes</u>. 1 For all problems in this section, use Fort Knox Special Map 30, or Vine Grove Map, 1:50,000.

2 Write your answers in the spaces provided.

(k) Requirements: Determine the percent-of-slope for each of the following problems:

A. Beginning elevation 160 meters, end elevation 240 meters, horizontal distance 400 meters.

Percent-of-slope ____________%

<u>Note</u>. Usually you need not determine beginning and ending elevations. Knowing the contour interval, you may simply count contour lines to determine the elevation difference. <u>In the examples below, assume that the contour interval is 10 meters for both questions.</u>

Count each contour line as an increase, including the first line. All are uphill.

B. Horizontal distance of 300 meters, 9 contour lines of vertical distance.

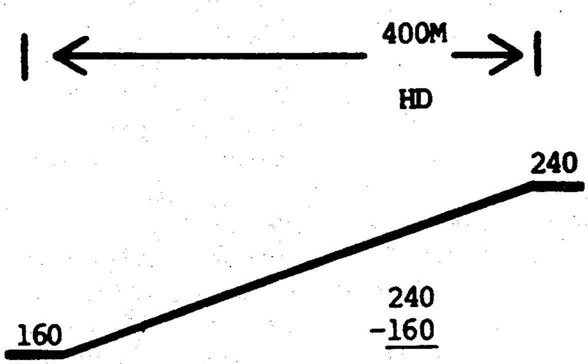
Percent-of-slope __________%

C. Horizontal distance of 600 meters, 9 contour lines of vertical distance.

Percent-of-slope __________%

ANSWERS

A.



$$\begin{array}{r} 240 \\ -\underline{160} \end{array}$$

VD=80

$$\frac{80 \times 100 = 8000}{HD \text{---} 400} = +20\%$$

Contour Interval X 9 = VD 90

B. $90 \times 100 = \frac{9000}{300} = +\underline{30\%}$

C. $90 \times 100 = \frac{9000}{600} = +15\%$

Figure 3-20. Answers to requirements.

(1) Requirements (cont): Determine the percent-of-slope for each of the following problems. Remember

to state whether the slope is positive (up) or negative (down):

A. From the pipeline/road junction, vicinity FS 055835 east to the RJ, vicinity FS 079827.

Percent-of-slope is ________.

B. From the RJ, vicinity FS 031875 to the road/ trail junction, vicinity FS 036878.

Percent-of-slope is ________.

C. From RJ 246 (ES 9582) east along highway 434 to Colesburg (FS 0782).

Percent-of-slope is ________.

D. From FS 080853 south and east along the pipeline to Mud Creek (FS 0985).

Percent-of-slope is ________.

Note. To determine percent-of-slope accurately, one must actually be on the slope and use one of several measuring devices. The following answers are an approximate percent-of-slope. Your answers will vary, depending upon where you determine the steepest part of the slope to be. Your answers should be within ± 5 percent of the answers below.

Figure 3-21. Problem A: Answer.

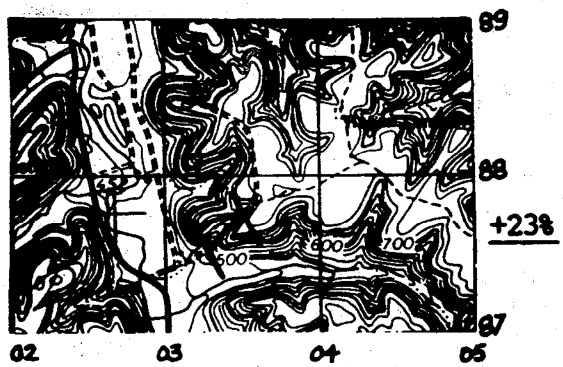


Figure 3-22. Problem B: Answer.

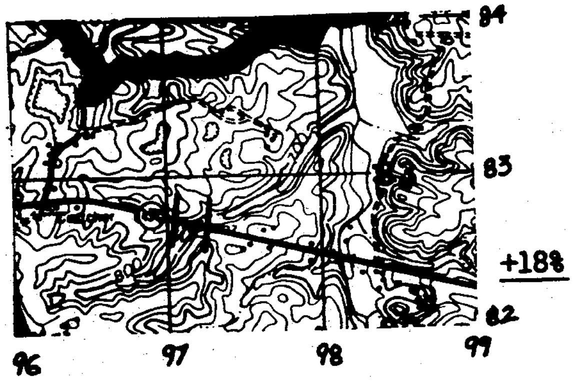


Figure 3-23. Problem C: Answer.

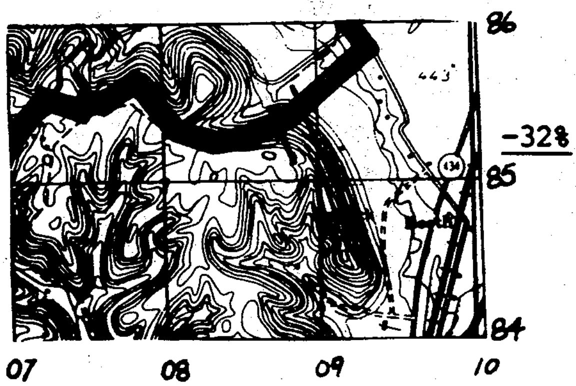


Figure 3-24. Problem D: Answer.

b. Practice Exercise—Objective 8.

(1) In this subcourse, reference point from which vertical measurements or elevations are taken is known as

   (a) mean sea level.
   (b) above-ground level.
   (c) datum plane.
   (d) tangent plane.

(2) Elevation is defined as

   (a) height above a datum plane.
   (b) depth below datum plane.
   (c) average height above sea level.
   (d) horizontal distance tangent to a vertical plane.

(3) Contour lines evenly spaced at the top and widely spread at the bottom indicate a ________ slope.

   (a) concave
   (b) convex
   (c) inverted
   (d) counter

(4) To actually determine the percent-of-slope one must be __________ the slope and use ___________ measuring devices.

   (a) near exact
   (b) on twenty
   (c) near several
   (d) on several

(5) Every contour line is important in determining elevation. The ___________ is numbered and _________ than the rest that give its elevation.

   (a) index heavier
   (b) fourth heavier
   (c) index lighter
   (d) fourth lighter

c. <u>Solutions to Practice Exercise--Objective 8.</u>

(1) (c) datum plane.
(2) (a) height above a datum plane.
(3) (a) concave
(4) (d) on several
(5) (a) index heavier

3-3. LEARNING ACTIVITY—OBJECTIVE 9

Upon completion of this learning activity, you will understand how to construct intervisibility profiles to determine one's ability to observe terrain in a given sector on the map.

a. Study Resources—Objective 9.

(1) Intervisibility is the ability to see one point on the ground from another point on the ground. This technique is also referred to as "line of sight." Knowledge of intervisibility is tactically very important for such uses as:

(a) Determining whether or not you are able to fire direct-fire weapons at a given target.

(b) Determining if you can be seen from a particular point. In most instances, a simple visual inspection will answer the question.

(2) A number of factors must be considered in determining intervisibility.

(a) Time of day--full light, night, dawn, dusk.

(b) Weather--fog, rain, snow, clear, slight haze.

(c) Vegetation--quantity, density, foliage.

(d) Relief--high/low ground, folds in terrain.

(e) Other--dust clouds, smoke, camouflage, fires.

(f) All of the factors must be considered in conjunction with each other. Most of them can vary in any given locale from minute to minute (or month to month). The one factor which is not a variable and can usually be determined without being on the ground is relief.

<u>Note</u>. In the four examples below a quick visual inspection tells you that you could see or fire from point A to point B. Note also that examples two and four have terrain features between points A and B. These terrain features are not masks or obstacles to vision, because they are not high enough to interfere with your line of sight.

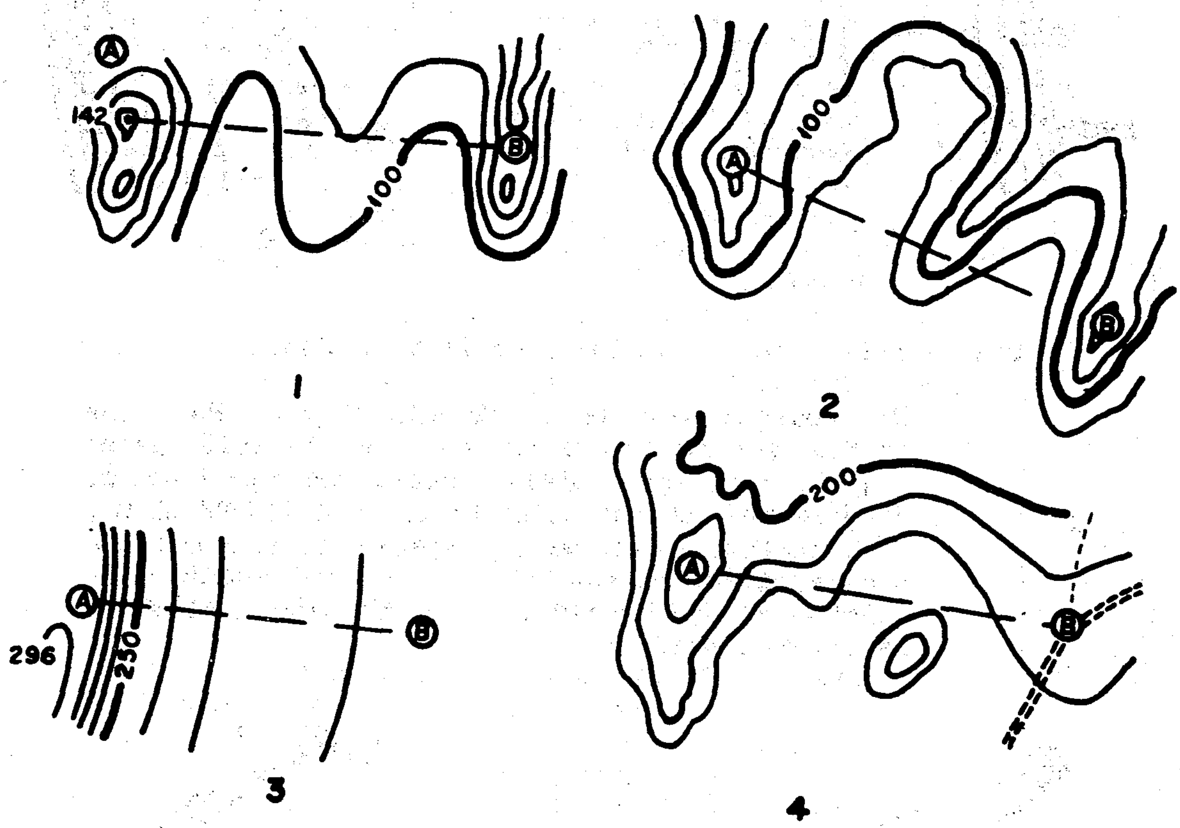


Figure 3-25. Example of intervisibility problems.

(3) On the next page there are two examples. Example one can be easily determined as offering intervisibility. How about example 2?

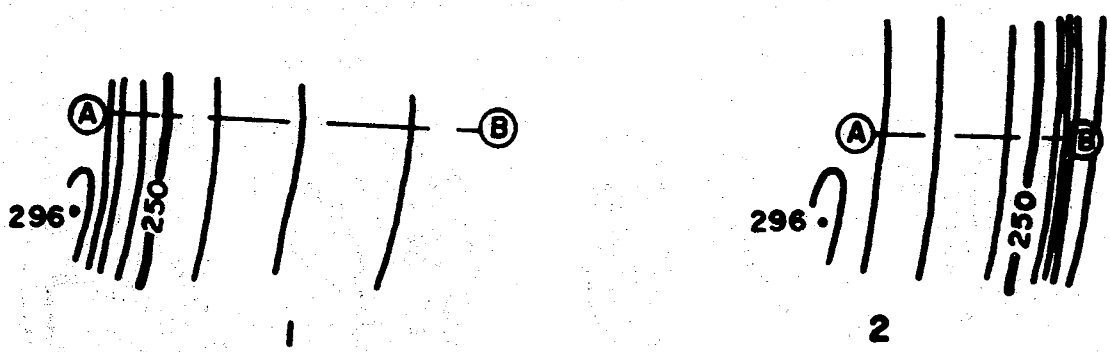


Figure 3-26. Intervisibility profiles (cont).

No. Example one is a CONCAVE slope. Note the contour pattern, with contour lines closely spaced at the top and widely spaced at the bottom. Example two, on the other hand, is a CONVEX slope, with contour lines widely spaced at the top and closely spaced at the bottom. You can remember the difference by concentration on the word CONCAVE--a cave goes inward.

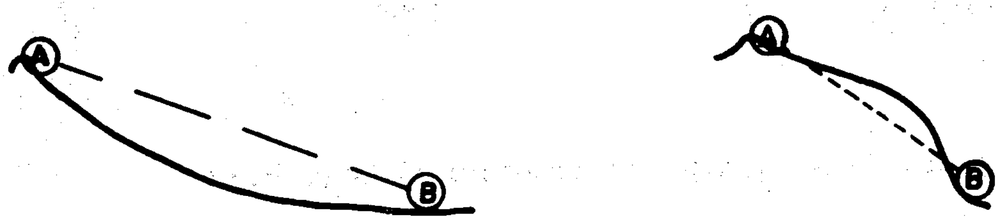


Figure 3-27. Intervisibility profiles (cont).

All of the foregoing examples are simple cases; all allow intervisibility to be easily determined by inspection. About 75 percent of your intervisibility problems can be solved by inspection.

(4) One way to determine intervisibility is to construct a terrain profile. We will construct a hasty profile for the line from point A to point B.

We first need to obtain a lined sheet of paper. Line spacing is not critical, as long as the lines are fairly uniform. You must have enough lines to allow one line for each contour elevation you will cross on the map between points.

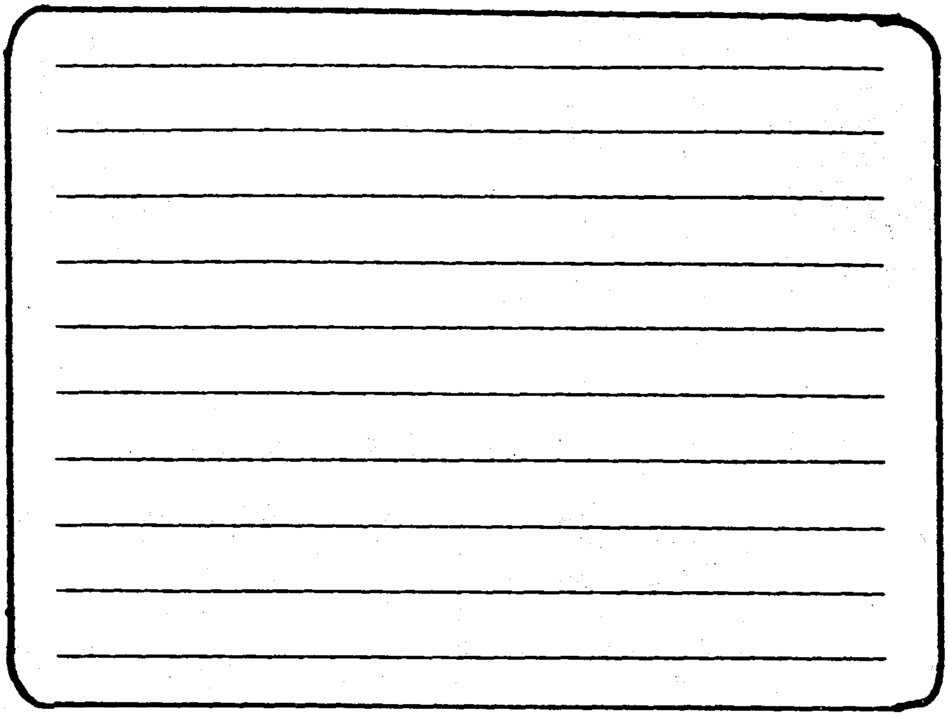


Figure 3-28. Lined Sheet.

(a) Determine the highest and lowest elevation on which we will be working.

<u>1</u> The highest elevation of line A-B is about 285 meters; the lowest is about 205 meters.

<u>2</u> Label the lines with the highest to the lowest elevation, or 290, 280, 270, and so on, down to 200.

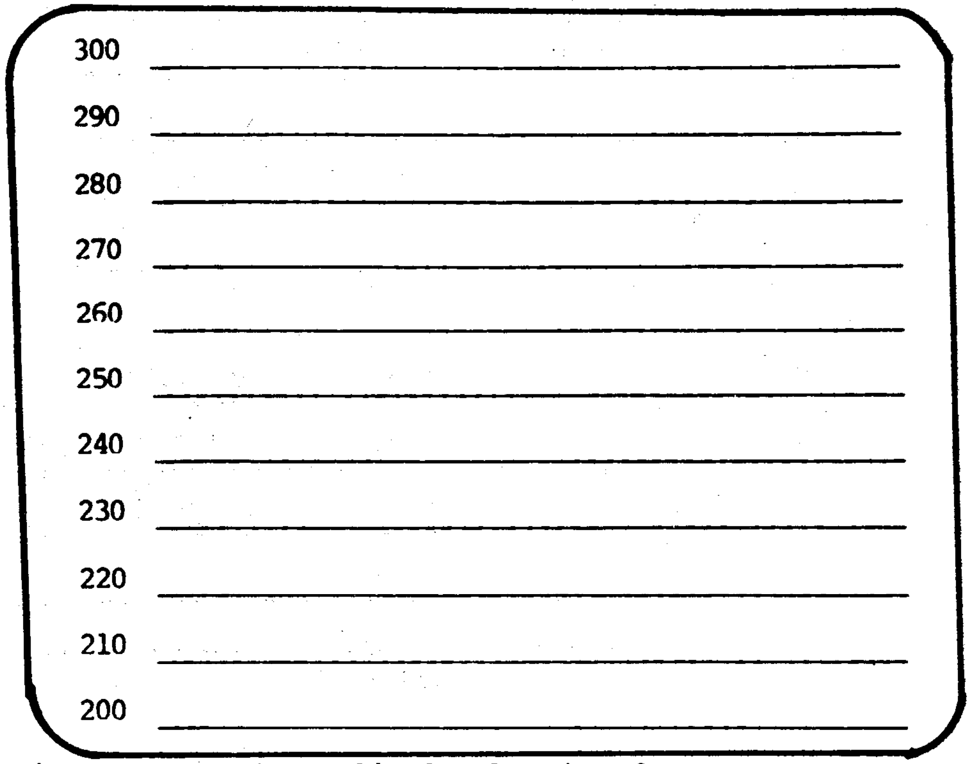


Figure 3-29. Sheet, lined and numbered.

(b) Place the lined piece of paper directly on line A-B; lines of the paper should be parallel to line A-B.

(c) Starting at point A, draw a vertical line of the lined paper to the corresponding elevation (285 meters).

(d) Moving to the right, search for the next significant terrain feature on the line of sight (point X). Draw a vertical line from point X on the lined paper to the corresponding elevation, 210 meters.

(e) Proceed further right to the next terrain feature, point B, and repeat the process.

(f) Connect the bottom tips of the lines you have drawn--we have done this with dashes (fig 3-30).

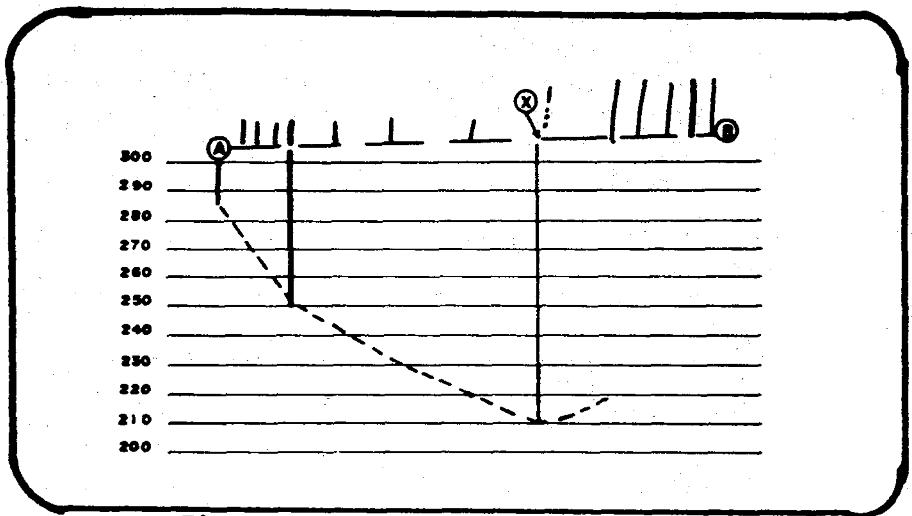


Figure 3-30. Solution.

(5) Another way to determine intervisibility is by line-of-sight determination.

(a) Determine if we have line of sight from point A to point B (fig 3-31). Point A is at an elevation of 252 meters. The elevation of point B is 265 meters.

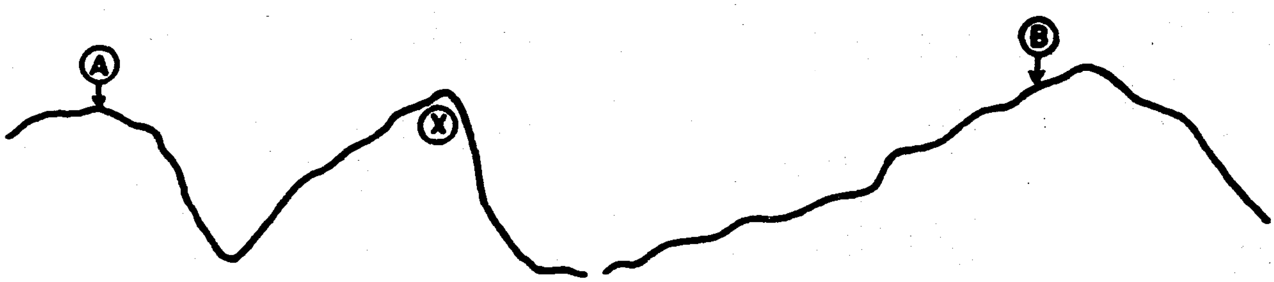


Figure 3-31. Line-of-sight determination.

Question: Is the ridge labeled X, with an elevation of less than 260 meters, a mask?

Answer: Yes, it is--barely. Place the edge of a piece of paper directly on points A and B. You will see that point X rises above the edge.

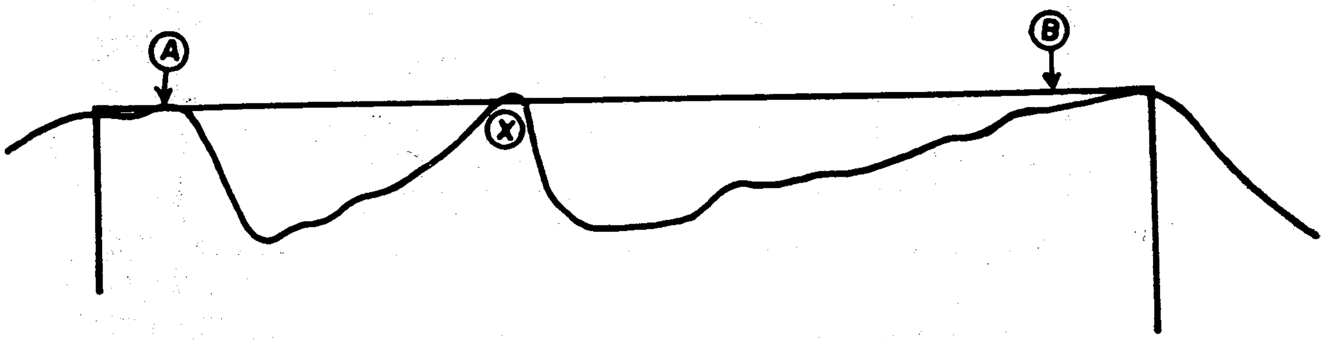
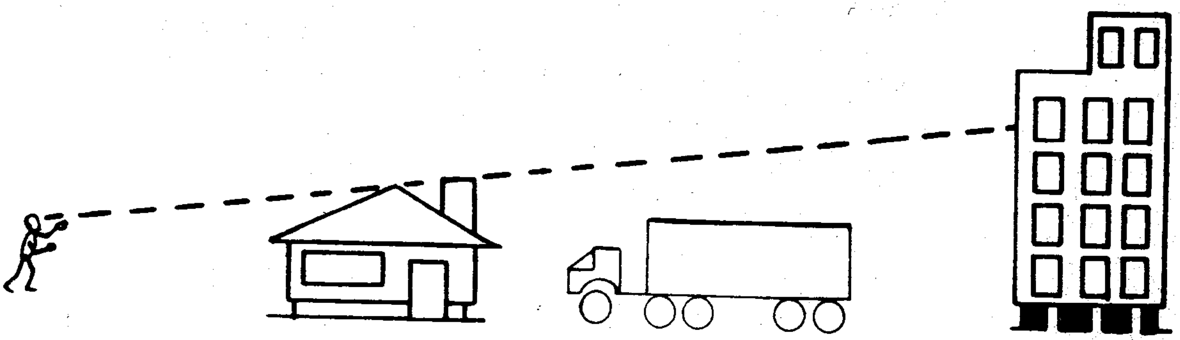
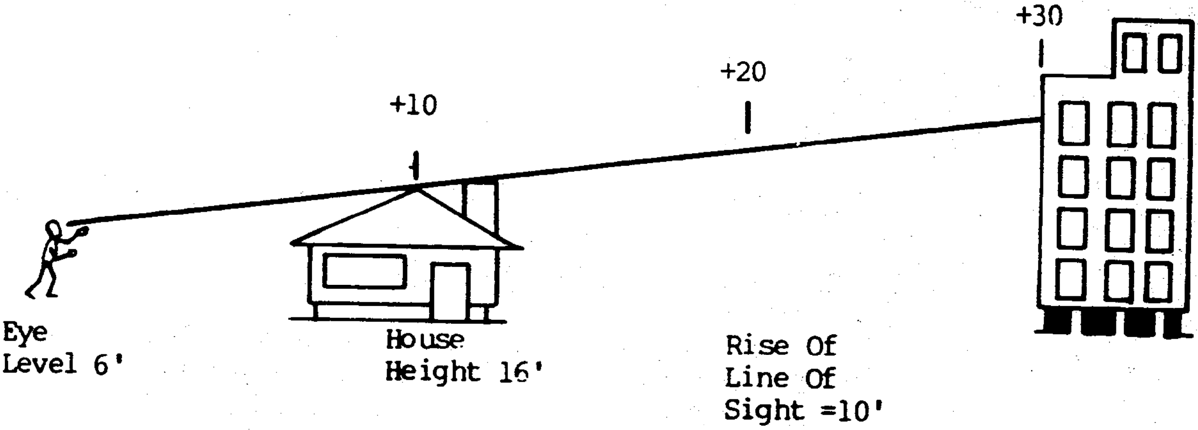


Figure 3-32. Line of sight (cont).

This is easily determined on a profile. Believe it or not, it is just as easily determined on the horizontal surface of the map. Remember—your line of sight is always a straight line.

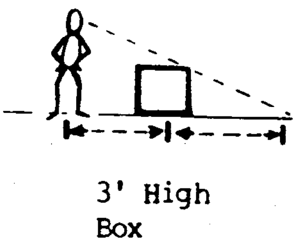


You can look over the house and see the tall building, but you cannot see the truck, it is masked. Let's look at the mathematics involved:



DISTANCE FROM MAN TO HOUSE. ACTUAL DISTANCE IS NOT IMPORTANT. JUST REMEMBER THAT ALONG HIS LINE-OF-SIGHT EACH TIME HE GOES FURTHER OUT THE SAME DISTANCE, HIS LINE-OF-SIGHT MUST RISE 10 MORE FEET.

THE PRINCIPLE IS THE SAME LOOKING DOWNWARD.



THE LINE-OF-SIGHT DROPS 3' EACH TIME THE SAME HORIZONTAL DISTANCE IS COVERED.

Figure 3-33. Line of sight (cont).

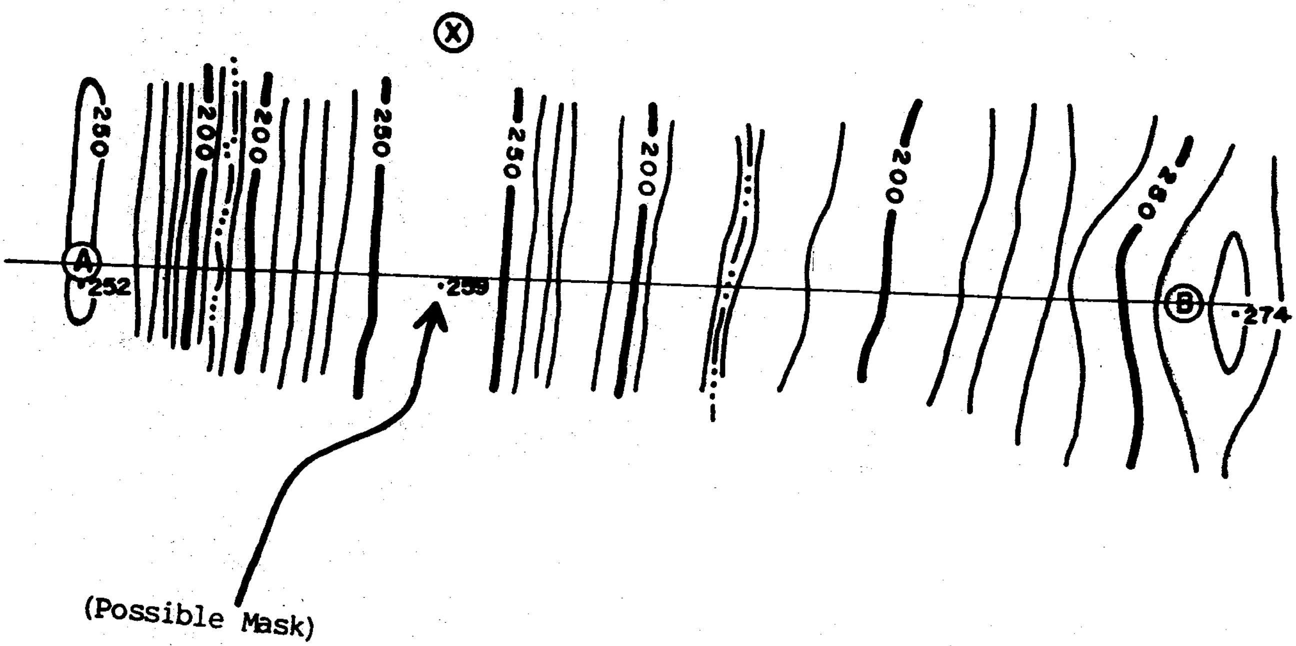


Figure 3-34. Determining terrain mask.

(b) Draw a line on the map with a straightedge, between the point where you are located (or will be) and your objective. Then, remove the paper and determine where any possible masks are located.

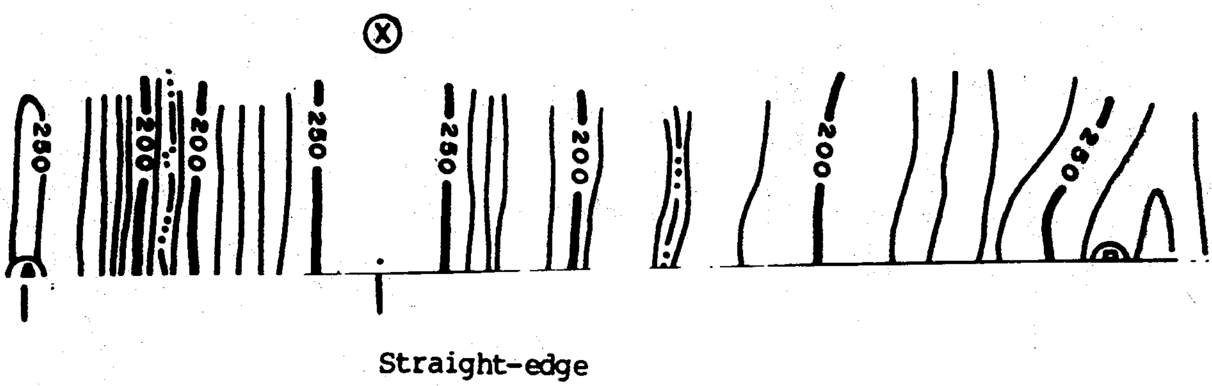


Figure 3-35. Determining terrain mask (cont).

(c) Place the paper or straightedge back on the map, touching the line. Make a tick mark on your straightedge at your location. Then, make a second tick mark on the straightedge at the point where the drawn line intersects the highest point on the mask.

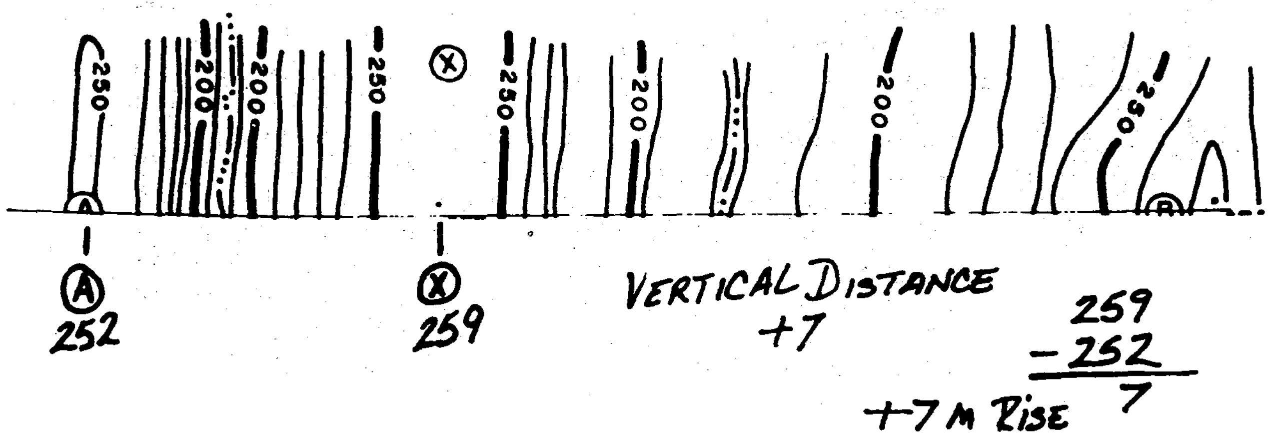


Figure 3-36. Determining terrain mask (cont).

(d) The distance between these two tick marks indicates the vertical rise or fall of your line of sight. Remember, <u>it makes no difference what horizontal distance is covered</u>. As long as you are looking along the same line, each time you repeat the horizontal distance the line of sight will rise (or fall) the same vertical distance.

(e) The vertical distance is the difference between point A (the first tick mark) at an elevation of 252 meters and point X (the second tick mark) at an elevation of 259 meters. Thus, the vertical distance is 7 meters.

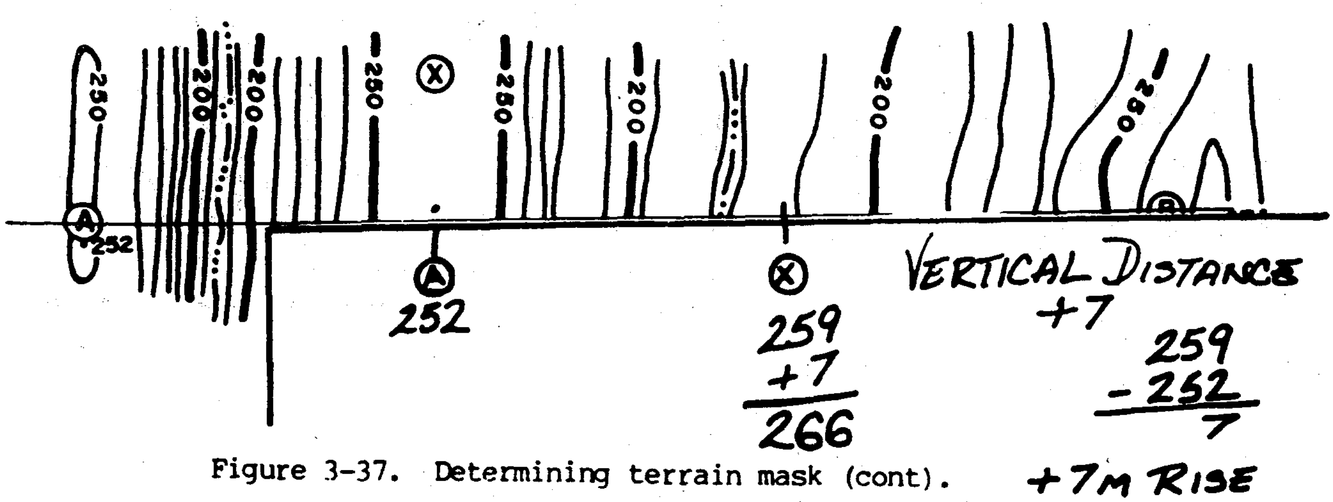


Figure 3-37. Determining terrain mask (cont).

(f) Slide the straightedge to the right so that our first tick mark is located at point X. This places our second tick mark to the right of point X.

(g) The line of sight rose 7 meters from point A to point X. Moving further along the line for the same distance, the line of sight will rise 7 more meters. Where the second tick mark lies on the map after the movement of the straightedge directly along the line, our line of sight will allow us to see everything above 266 meters. Anything lying below this elevation would be hidden or masked.

(h) Repeat the process by making a tick mark on the map at the new location on the second straightedge tick mark. Then, slide the straightedge to the right along the line. The second straightedge tick mark falls directly over the objective, at an elevation of 265 meters. The line of sight has risen a total of 21 meters, or to 273 meters. Thus, point B is below the line of sight from point A.

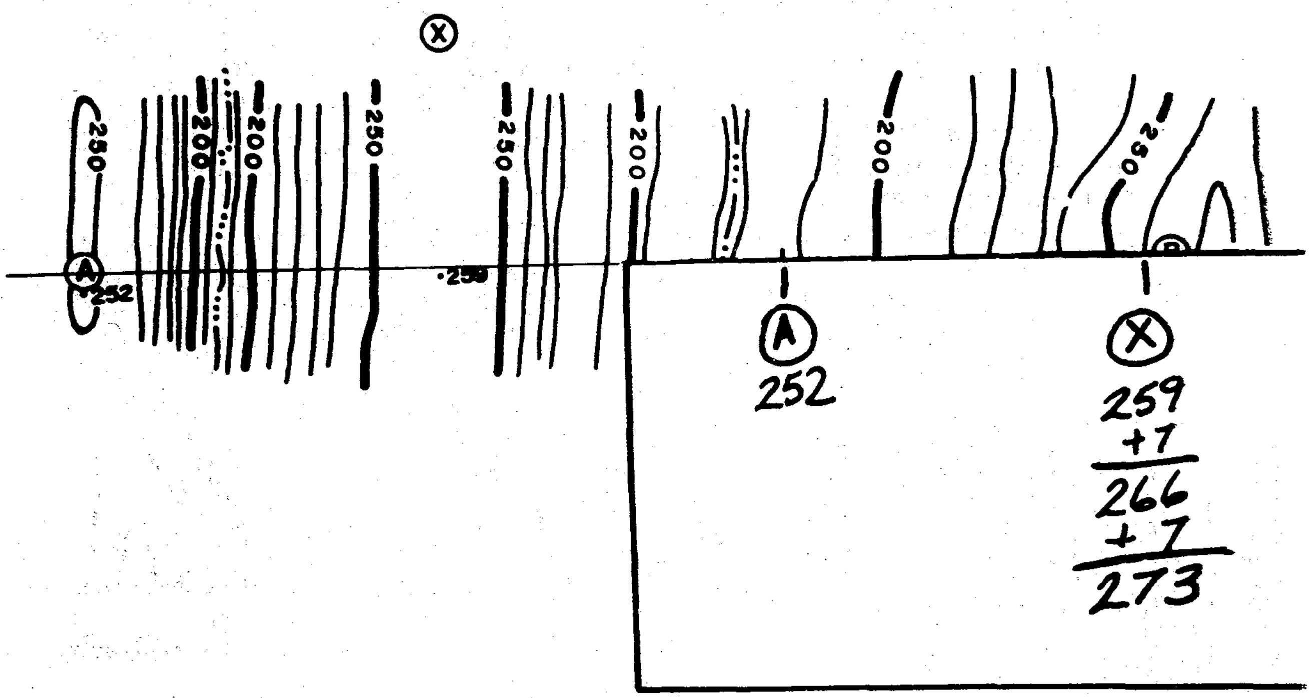


Figure 3-38. Solution.

b. Practice Exercise—Objective 9.

(1) When you are about to observe one point on the ground from another point on the ground, the method of observation is known as
   (a) intervisibility.
   (b) interchangeability.
   (c) interobservation.
   (d) interresponsibility.

(2) Another name for intervisibility is
   (a) line of opportunity.
   (b) line of orientation.
   (c) line of departure.
   (d) line of sight.

(3) Three, of several factors that must be considered in determining intervisibility are
   (a) time of day, weather, and position of the stars.
   (b) time of day, weather, and declination on the map.
   (c) time of day, weather, and shadow tip.
   (d) time of day, weather, and vegetation.

(4) Approximately 75 percent of your intervisibility problems can be easily determined by _____________.
   (a) instructions.
   (b) reformation.
   (c) decomposition.
   (d) inspection.

(5) One way to determine intervisibility is to construct a(n)
   (a) terrain profile.
   (b) azimuth profile.
   (c) interchange profile.
   (d) declination profile.

c. <u>Solution to Practice Exercise--Objective 9</u>.

(1) (a) intervisibility.

(2) (d) line of sight.

(3) (d) time of day, weather, and vegetation.

(4) (d) inspection.

(5) (a) terrain profile.

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